GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. _____

Project No. A-3652 — GTRI/~~GXX~~ — DATE 9 / 15 / 83

Project Director: T. B. Elfe — ~~School~~/Lab EMSL

Sponsor: McDonnell Douglas Astronautics

Type Agreement: Contract No. 83611320 H

Award Period: From 8/15/83 To ~~10/14/83~~ 12/3/83 (Performance) ~~10/14/83~~ 12/1/83 (Reports)

Sponsor Amount:	This Change:	Total to Date
Estimated:	$ 14,456	$ 14,456
Funded:	$ 14,456	$ 14,456

Cost Sharing Amount: $ _____ Cost Sharing No: _____

Title: "Optical Modeling and Analysis for Parabolic Dish Concentrator Evaluations"

ADMINISTRATIVE DATA — OCA Contact Frank H. Huff X4820

1) Sponsor Technical Contact:

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Defense Priority Rating: N/A — Military Security Classification: N/A

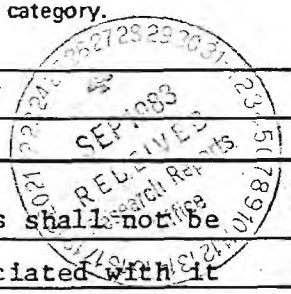
(or) Company/Industrial Proprietary: _____

RESTRICTIONS

See Attached _____ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with None proposed or authorized.



COMMENTS:

In the event travel is not required, McDonnell Douglas Astronautics shall not be obligated to pay the amount set forth for travel and overhead associated with it (amount is $1,686.73).

COPIES TO:

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Accounting	Research Communications (2)	Other

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date January 27, 1984

Project No. A-3652 ~~School~~/Lab EMSL

Includes Subproject No.(s)

Project Director(s) T. B. Elfe GTRI / ~~GIT~~

Sponsor McDonnell Douglas Astronautics

Title "Optical Modeling and Analysis for Parabolic Dish Concentrator Evaluations"

Effective Completion Date: 12/30/83 (Performance) 12/30/83 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [X] Closing Documents
- [X] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

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Research Communications (2)
Project File
Other

INTRODUCTION

This letter report is prepared to summarize the optical analysis work which Georgia Tech has performed for McDonnell Douglas Astronautics Company on Georgia Tech Project A-3652. The structure analyzed was a faceted solar concentrator. The report covers major assumptions in the code and includes input conditions and results.

ASSUMPTIONS IN CODE

The optical analysis program assumes that each facet center is located on a paraboloid having a focal length of 7 meters. Transverse coordinates of facet centers were supplied by McDonnell Douglas. It is further assumed that the normal to the facet at its center coincides with that of the paraboloid on which the facet centers are located. It is further assumed that the radius of curvature of each facet can be chosen to be optimum.

We generate a data file which contains the coordinate of the centers of curvature and radii of curvature of all the facets. This data file is used by the optical analysis program, as will be explained later.

Each facet is covered with a grid of 441 points. At each of these points, the facet normal equation is calculated and 13 rays from the solar disk are reflected about that point, having first applied a normally distributed slope error to the direction of the normal.

The sun model consists of a central ray which is assumed to travel parallel to the optic axis of the concentrator, and rings of 4 equally spaced rays, making angles of 6, 10, and 14 minutes with respect to the central ray, each ring of non-central rays being rotated randomly. Rays from the solar disk model are weighted according to the areas they represent and further by the factors 1, 0.97, 0.86, and 0.69 to account for limb darkening. Due to the large number of patterns we calculated with

zero slope error, we should have included a randomization of the angles of non-central rays, but this was not discovered in time to implement the better model, and in any event is not expected to cause major difficulties.

The rays are further weighted by the cosine of the angle which the facet center normal makes with the optic axis. This factor can also be used to calculate total flux, once insolation and reflectivity are assumed. The rays are collected on whatever surface is desired (standard subroutines are the conical and plane collecting surfaces). Typical collection segments are 10^{o} x 1 cm. From the collected weights, we make flux contour plots

INPUT CONDITIONS

The facet layout is shown in Figure 1 and is described quantitatively in Table I. The handwritten numbers on the facets in Figure 1 constitute a re-numbering by Georgia Tech for convenience in fitting them into our logic. Other input parameters are flux leaving concentrator (or that part of the concentrator being analyzed), type of collector surface, location of collector surface, slope error, and collection ring width. In addition, facet radii of curvature are, in effect, an input condition. Tables II and III are two input files. In Table II, radii of curvature are averaged from the ideal radial and circumferential values. In Table III, a weighted average was used for some of the facets. The lines not discussed are keys which determine branch directions in the program.

RESULTS

Figures 2-7 are focal plane flux plots from facets 10, 81, and 84 (Georgia Tech numbering system) for 0 and 1 m radian slope errors. Figures

FIGURE 1

Facet Layout

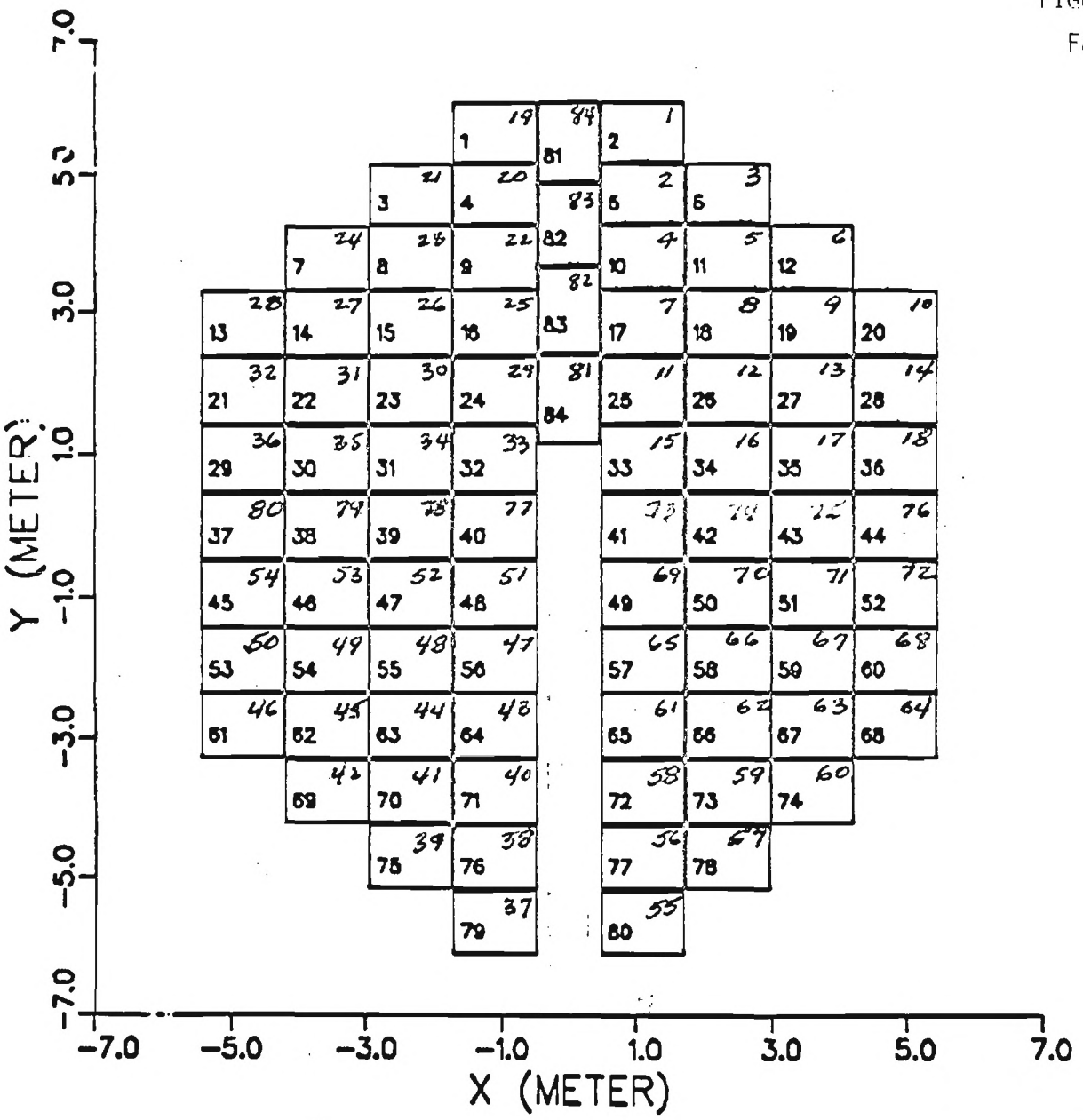

TABLE I

PANEL #	X POS	Y POS	X DIMENSION	Y DIMENSION
1	-1.0920	5.6390	1.2129	.9081
2	1.0920	5.6390	1.2129	.9081
3	-2.3370	4.6990	1.2129	.9081
4	-1.0920	4.6990	1.2129	.9081
5	1.0920	4.6990	1.2129	.9081
6	2.3370	4.6990	1.2129	.9081
7	-3.5810	3.7590	1.2129	.9081
8	-2.3370	3.7590	1.2129	.9081
9	-1.0920	3.7590	1.2129	.9081
10	1.0920	3.7590	1.2129	.9081
11	2.3370	3.7590	1.2129	.9081
12	3.5810	3.7590	1.2129	.9081
13	-4.8260	2.8190	1.2129	.9081
14	-3.5810	2.8190	1.2129	.9081
15	-2.3370	2.8190	1.2129	.9081
16	-1.0920	2.8190	1.2129	.9081
17	1.0920	2.8190	1.2129	.9081
18	2.3370	2.8190	1.2129	.9081
19	3.5810	2.8190	1.2129	.9081
20	4.8260	2.8190	1.2129	.9081
21	-4.8260	1.8800	1.2129	.9081
22	-3.5810	1.8800	1.2129	.9081
23	-2.3370	1.8800	1.2129	.9081
24	-1.0920	1.8800	1.2129	.9081
25	1.0920	1.8800	1.2129	.9081
26	2.3370	1.8800	1.2129	.9081
27	3.5810	1.8800	1.2129	.9081
28	4.8260	1.8800	1.2129	.9081
29	-4.8260	.9400	1.2129	.9081
30	-3.5810	.9400	1.2129	.9081
31	-2.3370	.9400	1.2129	.9081
32	-1.0920	.9400	1.2129	.9081
33	1.0920	.9400	1.2129	.9081
34	2.3370	.9400	1.2129	.9081
35	3.5810	.9400	1.2129	.9081
36	4.8260	.9400	1.2129	.9081
37	-4.8260	0.0000	1.2129	.9081
38	-3.5810	0.0000	1.2129	.9081
39	-2.3370	0.0000	1.2129	.9081
40	-1.0920	0.0000	1.2129	.9081
41	1.0920	0.0000	1.2129	.9081
42	2.3370	0.0000	1.2129	.9081
43	3.5810	0.0000	1.2129	.9081
44	4.8260	0.0000	1.2129	.9081

→ ALL VALUES IN METERS

→ PANEL NUMBER RELATES TO FIGURE

→ X & Y DIMENSIONS ARE FOR GLASS

→ DIS# FOCAL LENGTH = 7.0 M

→ X & Y POSITIONS ARE PANEL CENTERS

(CONTINUED NEXT PAGE)

45	-4.8260	-.9400	1.2129	.9081
46	-3.5810	-.9400	1.2129	.9081
47	-2.3370	-.9400	1.2129	.9081
48	-1.0920	-.9400	1.2129	.9081
49	1.0920	-.9400	1.2129	.9081
50	2.3370	-.9400	1.2129	.9081
51	3.5810	-.9400	1.2129	.9081
52	4.8260	-.9400	1.2129	.9081
53	-4.8260	-1.8800	1.2129	.9081
54	-3.5810	-1.8800	1.2129	.9081
55	-2.3370	-1.8800	1.2129	.9081
56	-1.0920	-1.8800	1.2129	.9081
57	1.0920	-1.8800	1.2129	.9081
58	2.3370	-1.8800	1.2129	.9081
59	3.5810	-1.8800	1.2129	.9081
60	4.8260	-1.8800	1.2129	.9081
61	-4.8260	-2.8190	1.2129	.9081
62	-3.5810	-2.8190	1.2129	.9081
63	-2.3370	-2.8190	1.2129	.9081
64	-1.0920	-2.8190	1.2129	.9081
65	1.0920	-2.8190	1.2129	.9081
66	2.3370	-2.8190	1.2129	.9081
67	3.5810	-2.8190	1.2129	.9081
68	4.8260	-2.8190	1.2129	.9081
69	-3.5810	-3.7590	1.2129	.9081
70	-2.3370	-3.7590	1.2129	.9081
71	-1.0920	-3.7590	1.2129	.9081
72	1.0920	-3.7590	1.2129	.9081
73	2.3370	-3.7590	1.2129	.9081
74	3.5810	-3.7590	1.2129	.9081
75	-2.3370	-4.6990	1.2129	.9081
76	-1.0920	-4.6990	1.2129	.9081
77	1.0920	-4.6990	1.2129	.9081
78	2.3370	-4.6990	1.2129	.9081
79	-1.0920	-5.6390	1.2129	.9081
80	1.0920	-5.6390	1.2129	.9081
81	0.0000	5.4870	.9081	1.2129
82	0.0000	4.2420	.9081	1.2129
83	0.0000	3.0000	.9081	1.2129
84	0.0000	1.7530	.9081	1.2129

TABLE II

Input File

```
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 8.662361   -.064833   -.278982   15.687016
 8.967297   -.164200   -.330156   16.001816
 8.094467   -.042685   -.146934   15.105159
 8.399403   -.116801   -.187871   15.416879
 8.925260   -.246228   -.258468   15.958321
 7.652801   -.025460   -.065724   14.656606
 7.957737   -.079938   -.096425   14.965925
 8.483594   -.189742   -.149367   15.503234
 9.231216   -.384568   -.224637   16.275606
 7.337633   -.013168   -.022670   14.338651
 7.642569   -.053632   -.043145   14.646255
 8.168425   -.149435   -.078452   15.180610
 8.916048   -.330247   -.128650   15.948794
 7.148291   -.005784   -.004979   14.148487
 7.453226   -.037829   -.015216   14.455060
 7.979082   -.125219   -.032870   14.987639
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 8.967297    .164200   -.330156   16.001816
 8.094467    .042685   -.146934   15.105159
 8.399403    .116801   -.187871   15.416879
 8.925260    .246228   -.258468   15.958321
 7.652801    .025460   -.065724   14.656606
 7.957737    .079938   -.096425   14.965925
 8.483594    .189742   -.149367   15.503234
 9.231216    .384568   -.224637   16.275606
 7.337633    .013168   -.022670   14.338651
 7.642569    .053632   -.043145   14.646255
 8.168425    .149435   -.078452   15.180610
 8.916048    .330247   -.128650   15.948794
 7.148291    .005784   -.004979   14.148487
 7.453226    .037829   -.015216   14.455060
 7.979082    .125219   -.032870   14.987639
 8.726705    .297612   -.057968   15.753304
 9.356484    .091903    .474581   16.405990
 8.662361    .064833    .278982   15.687016
 8.967297    .164200    .330156   16.001816
 8.094467    .042685    .146934   15.105159
 8.399403    .116801    .187871   15.416879
 8.925260    .246228    .258468   15.958321
 7.652801    .025460    .065724   14.656606
 7.957737    .079938    .096425   14.965925
 8.483594    .189742    .149367   15.503234
 9.231216    .384568    .224637   16.275606
 7.337633    .013168    .022670   14.338651
 7.642569    .053632    .043145   14.646255
 8.168425    .149435    .078452   15.180610
 8.916048    .330247    .128650   15.948794
 7.148291    .005784    .004979   14.148487
 7.453226    .037829    .015216   14.455060
 7.979082    .125219    .032870   14.987639
 8.726705    .297612    .057968   15.753304
 9.356484   -.091903    .474581   16.405990
 8.662361   -.064833    .278982   15.687016
 8.967297   -.164200    .330156   16.001816
 8.094467   -.042685    .146934   15.105159
 8.399403   -.116801    .187871   15.416879
 8.925260   -.246228    .258468   15.958321
 7.652801   -.025460    .065724   14.656606
 7.957737   -.079938    .096425   14.965925
 8.483594   -.189742    .149367   15.503234
 9.231216   -.384568    .224637   16.275606
 7.337633   -.013168    .022670   14.338651
 7.642569   -.053632    .043145   14.646255
 8.168425   -.149435    .078452   15.180610
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 7.148291   -.005784    .004979   14.148487
 7.453226   -.037829    .015216   14.455060
 7.979082   -.125219    .032870   14.987639
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 9.150511   0.000000   -.421425   16.191751
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3.1413
1
0.30 62.6
0.
1.
0. .20
1
1.
441
```

TABLE III

Input File

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MDAT273
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    8.994834    -.090765    -.390574   16.038674
    9.360756    -.229880    -.462218   16.422012
    8.094467    -.042685    -.146934   15.105159
    8.679283    -.163521    -.263019   15.710414
    9.310311    -.344719    -.361854   16.368996
    7.652801    -.025460    -.065724   14.656606
    7.957737    -.079938    -.096425   14.965925
    8.780313    -.265639    -.209114   15.815279
    9.677459    -.538394    -.314491   16.756094
    7.337633    -.013168    -.022670   14.338651
    7.642569    -.053632    -.043145   14.646255
    8.168425    -.149435    -.078452   15.180610
    9.299257    -.462344    -.180109   16.357386
    7.148291    -.005784    -.004979   14.148487
    7.453226    -.037829    -.015216   14.455060
    7.979082    -.125219    -.032870   14.987639
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    9.360756     .229880    -.462218   16.422012
    8.094467     .042685    -.146934   15.105159
    8.679283     .163521    -.263019   15.710414
    9.310311     .344719    -.361854   16.368996
    7.652801     .025460    -.065724   14.656606
    7.957737     .079938    -.096425   14.965925
    8.780313     .265639    -.209114   15.815279
    9.677459     .538394    -.314491   16.756094
    7.337633     .013168    -.022670   14.338651
    7.642569     .053632    -.043145   14.646255
    8.168425     .149435    -.078452   15.180610
    9.299257     .462344    -.180109   16.357386
    7.148291     .005784    -.004979   14.148487
    7.453226     .037829    -.015216   14.455060
    7.979082     .125219    -.032870   14.987639
    9.072046     .416656    -.081156   16.119322
    9.827781     .128664     .664413   16.915410
    8.994834     .090765     .390574   16.038674
    9.360756     .229880     .462218   16.422012
    8.094467     .042685     .146934   15.105159
    8.679283     .163521     .263019   15.710414
    9.310311     .344719     .361854   16.368996
    7.652801     .025460     .065724   14.656606
    7.957737     .079938     .096425   14.965925
    8.780313     .265639     .209114   15.815279
    9.677459     .538394     .314491   16.756094
    7.337633     .013168     .022670   14.338651
    7.642569     .053632     .043145   14.646255
    8.168425     .149435     .078452   15.180610
    9.299257     .462344     .180109   16.357386
    7.148291     .005784     .004979   14.148487
    7.453226     .037829     .015216   14.455060
    7.979082     .125219     .032870   14.987639
    9.072046     .416656     .081156   16.119322
    9.827781    -.128664     .664413   16.915410
    8.994834    -.090765     .390574   16.038674
    9.360756    -.229880     .462218   16.422012
    8.094467    -.042685     .146934   15.105159
    8.679283    -.163521     .263019   15.710414
    9.310311    -.344719     .361854   16.368996
    7.652801    -.025460     .065724   14.656606
    7.957737    -.079938     .096425   14.965925
    8.780313    -.265639     .209114   15.815279
    9.677459    -.538394     .314491   16.756094
    7.337633    -.013168     .022670   14.338651
    7.642569    -.053632     .043145   14.646255
    8.168425    -.149435     .078452   15.180610
    9.299257    -.462344     .180109   16.357386
    7.148291    -.005784     .004979   14.148487
    7.453226    -.037829     .015216   14.455060
    7.979082    -.125219     .032870   14.987639
    9.072046    -.416656     .081156   16.119322
    7.085176    -.003322    0.000000   14.085241
    7.390112    -.032561    0.000000   14.391471
    7.915968    -.117147    0.000000   14.923458
    8.996308    -.401426    0.000000   16.040213
    7.085176     .003322    0.000000   14.085241
    7.390112     .032561    0.000000   14.391471
    7.915968     .117147    0.000000   14.923458
    8.996308     .401426    0.000000   16.040213
    7.219501    0.000000    -.013743   14.219931
    7.642857    0.000000    -.068879   14.646547
    8.285325    0.000000    -.194728   15.300069
    9.580614    0.000000    -.589995   16.653708
1 1
88.7877
1
0.300 62.6
0.
1.
0. 0.2
1
1.
441
1 2.
```

FIGURE 2

Facet 10, Focal Plane
Slope Error = 0
Power = 1.0229 kw
Peak Flux = 127.32
Contour Interval = 20

Flux Value at 90% Power:	20.23 KW/SQ M
Area Inside 90% Power Contour:	160.11 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

FIGURE 3

Facet 10, Focal Plane
Slope Error = 1.0 mRad.
Power = 1.0229 kw
Peak Flux = 99.03
Contour Interval = 20

Flux Value at 90% Power:	15.59 KW/SQ M
Area Inside 90% Power Contour:	182.43 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check)	.92 KILOWATTS

FIGURE 4

Facet 81, Focal Plane
Slope Error = 0
Power = 1.0929 kw
Peak Flux = 410.27
Contour Interval = 250

Flux Value at 90% Power:	184.44 KW/SQ M
Area Inside 90% Power Contour:	33.23 SQ CM
Power Inside 90% Power Contour:	.98 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

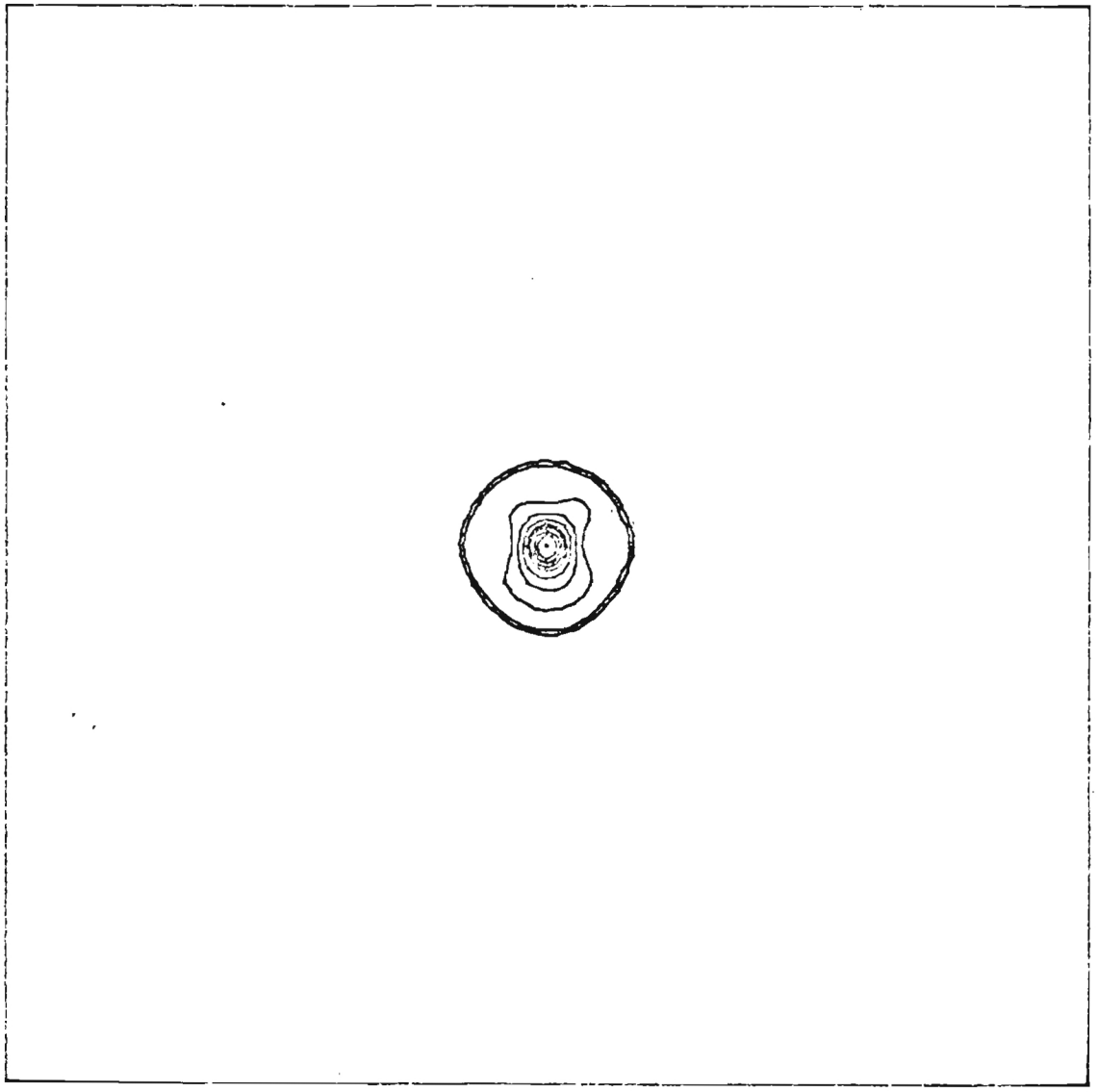


FIGURE 5

Facet 81, Focal Plane
Slope Error = 1.0 mRad.
Power = 1.0929 kw
Peak Flux = 339.53
Contour Interval = 50

Flux Value at 90% Power:	54.46 KW/SQ M
Area Inside 90% Power Contour:	51.05 SQ CM
Power Inside 90% Power Contour:	.99 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

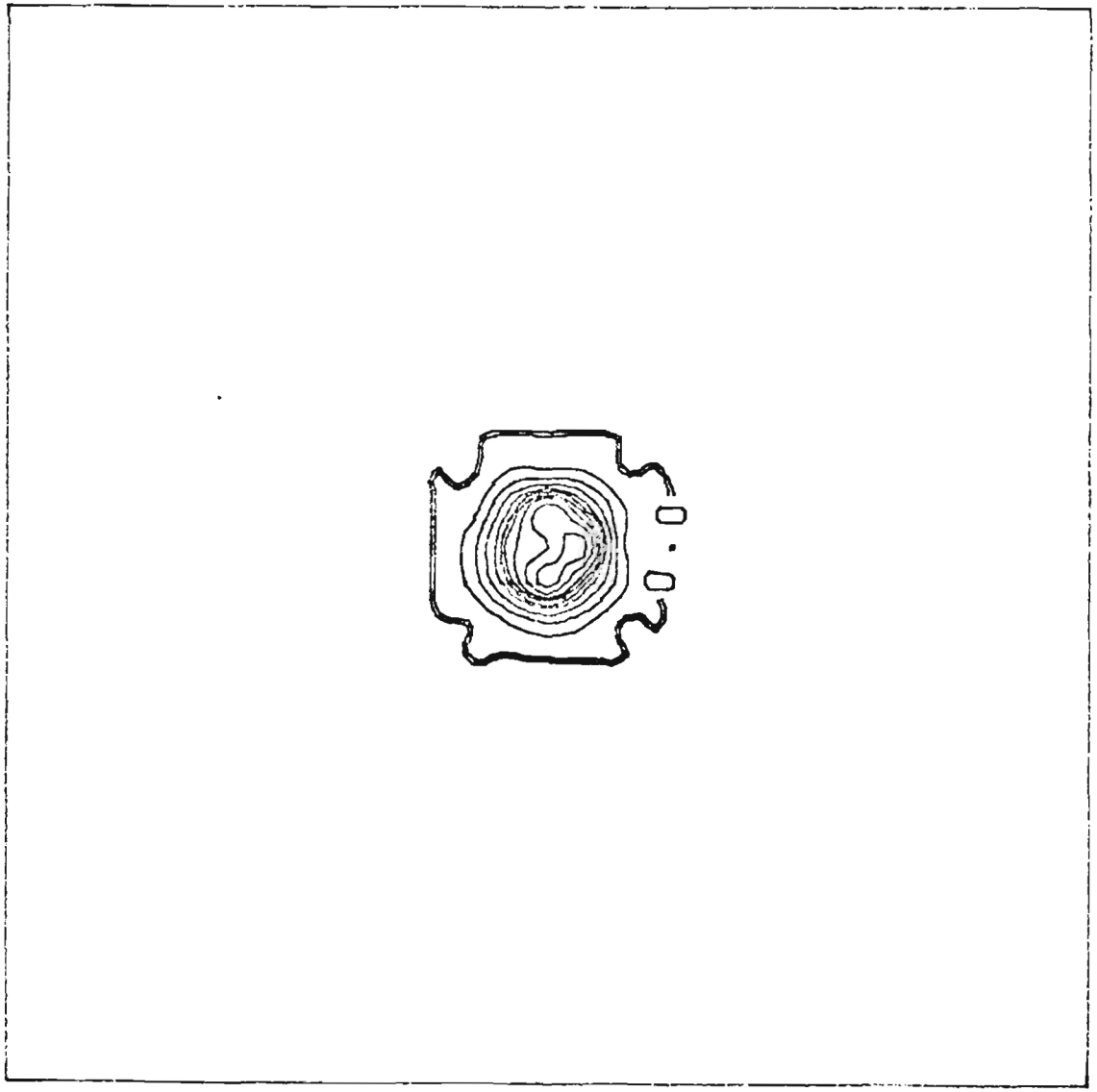


FIGURE 6

Facet 84, Focal Plane
Slope Error = 0
Power = 1.0255 kw
Peak Flux = 127.32
Contour Interval = 100

Flux Value at 90% Power:	22.07 KW/SQ M
Area Inside 90% Power Contour:	143.79 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.93 KILOWATTS

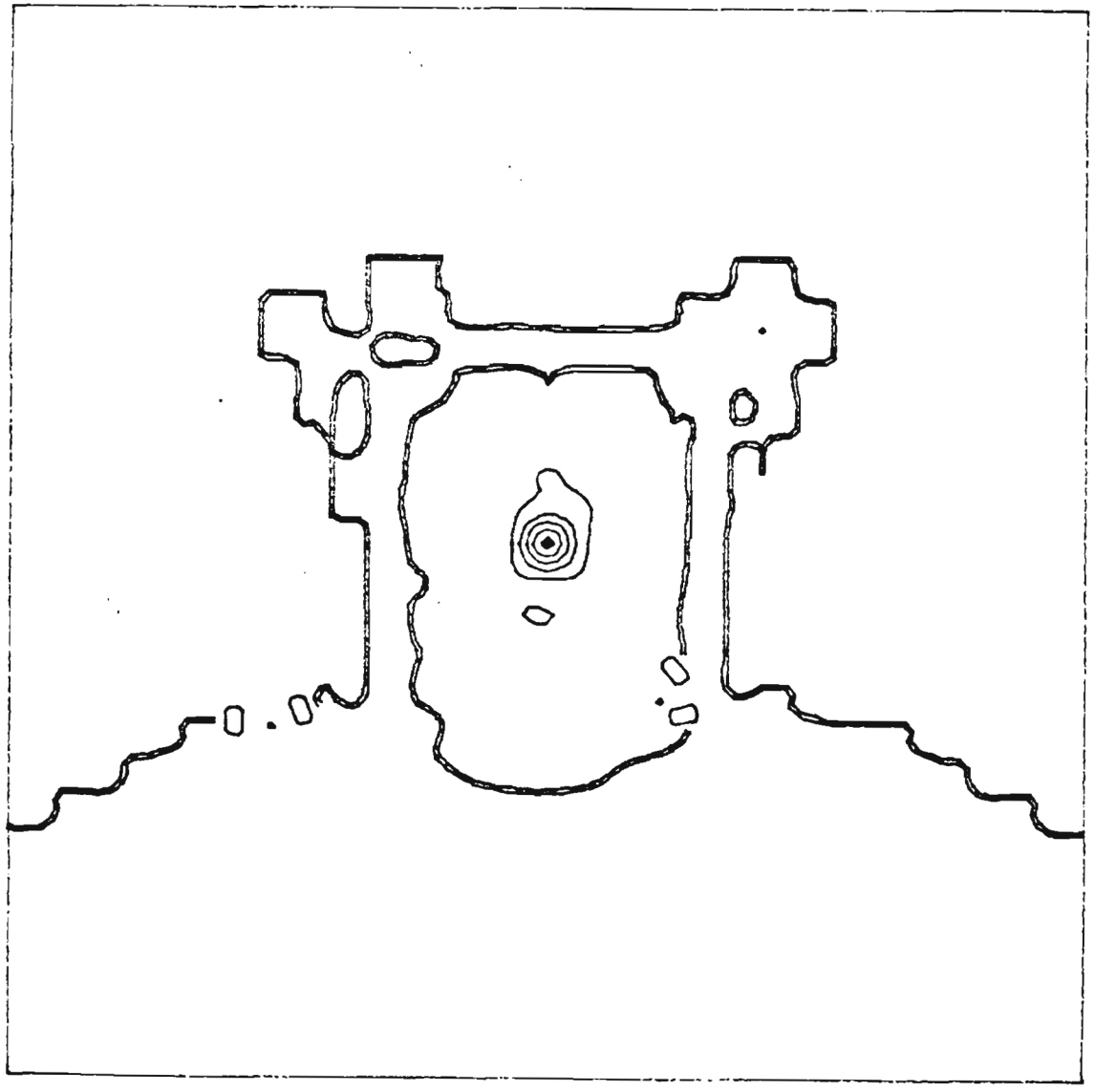
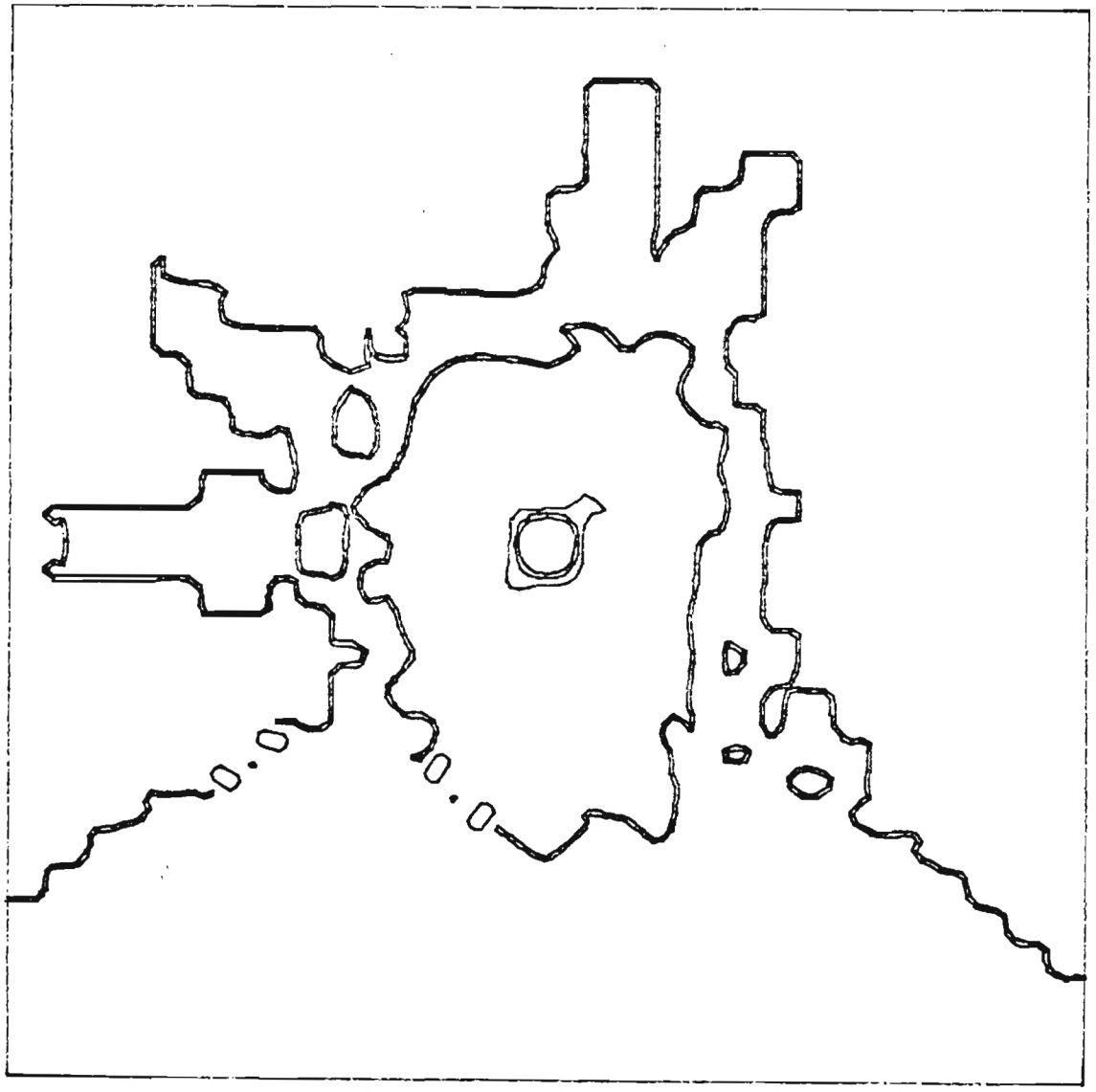


FIGURE 7

Facet 84, Focal Plane
Slope Error = 1.0 mRad.
Power = 1.0255 kw
Peak Flux = 113.18
Contour Interval = 100

Flux Value at 90% Power:	17.27 KW/SQ M
Area Inside 90% Power Contour:	173.81 SQ CM
Power Inside 90% Power Contour:	.93 KILOWATTS
90% Total Power (Check):	.93 KILOWATTS



8-13 are flux plots on a 62.6° cone with vertex 30 cm behind the focal plane for the same facets under the same conditions. "Peak" flux is averaged over the innermost 1.5 cm radius and is listed in kW/m^2. McDonnell Douglas supplied us with an algorithm to calculate the area encompassing 90 percent of the energy. Figures 14 and 15 are the composite of the 3 facets on the focal plane, while Figures 16 and 17 are the composite on the cone. The next 24 figures (18-41) show the effects of varying radius of curvature for facets 10, 81, and 84. RC:Rad is weighting of longer and shorter "optimal" radii of curvature.

Next, we have included aperture plane flux plots for the entire concentrator, using the best radii of curvature we found (Table III). Figures 44 and 45 are flux on a plane 15 cm behind the aperture plane, and Figures 46 and 47 are cone flux plots. Figures 48-53 show the effects of 1/2 and 1 m radian cant on the flux on the three facets described above. Figures 54-56 show the effect of a 2 m radian pointing error, while Figures 57-59 show the effect of a normally distributed radius of curvature error where σ = 10 cm. Unless otherwise marked all figures are 60 x 60 cm full scale.

CONCLUSIONS

While the aperture plane flux plot is not quite as small as is desirable, it appears that this concentrator is basically capable of powering a Stirling engine. The low flux area from the missing facets near the post will need to be eliminated, but this should be possible with a facet re-aiming by twisting technique.

FIGURE 8

Facet 10, Cone @ 30 cm
Slope Error = 0
Power = 1.0229 kw
Contour Interval = 20

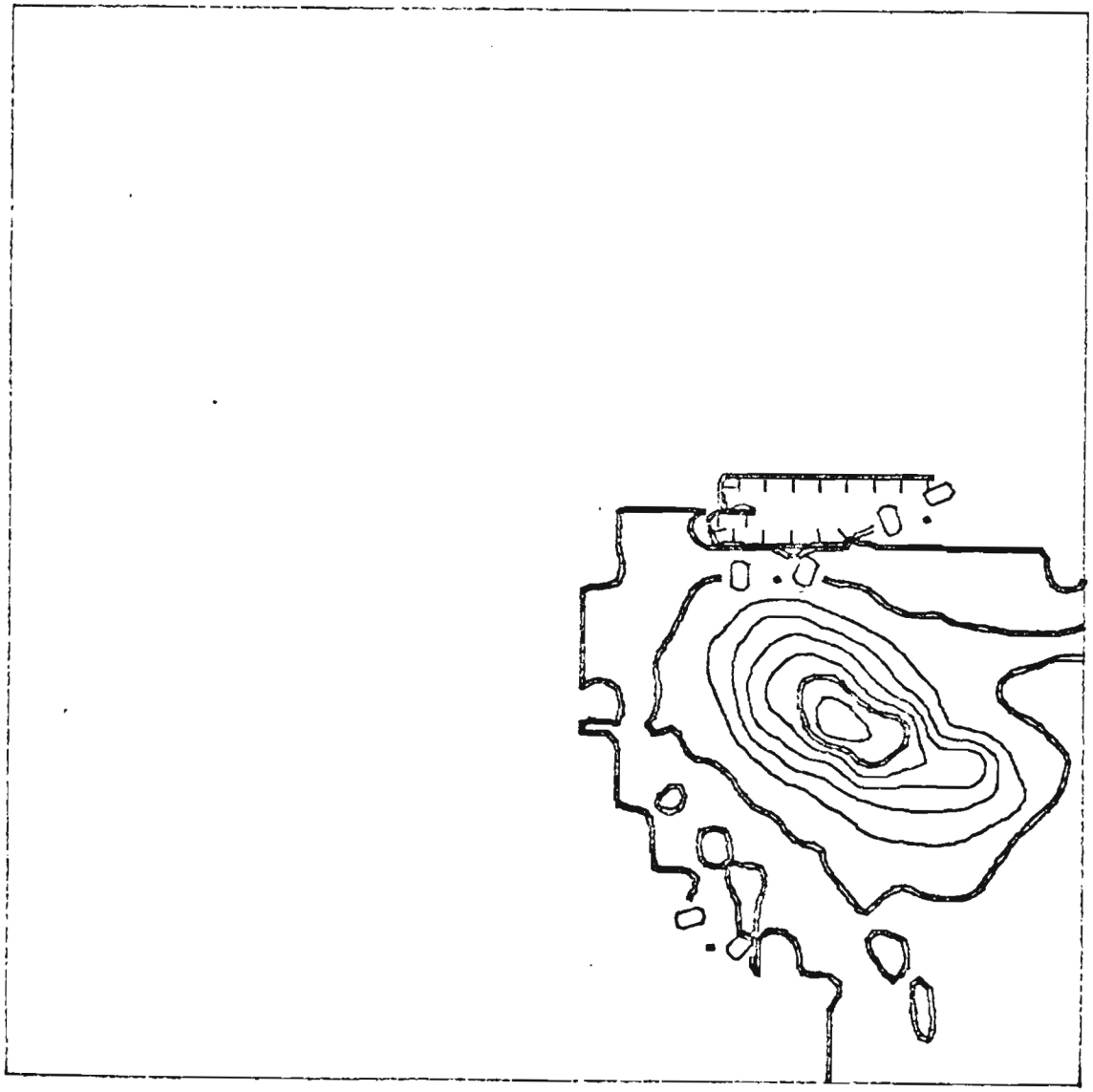


FIGURE 9

Facet 10, Cone @ 30 cm
Slope Error = 1.0 mRad.
Power = 1.0229 kw
Contour Interval = 20

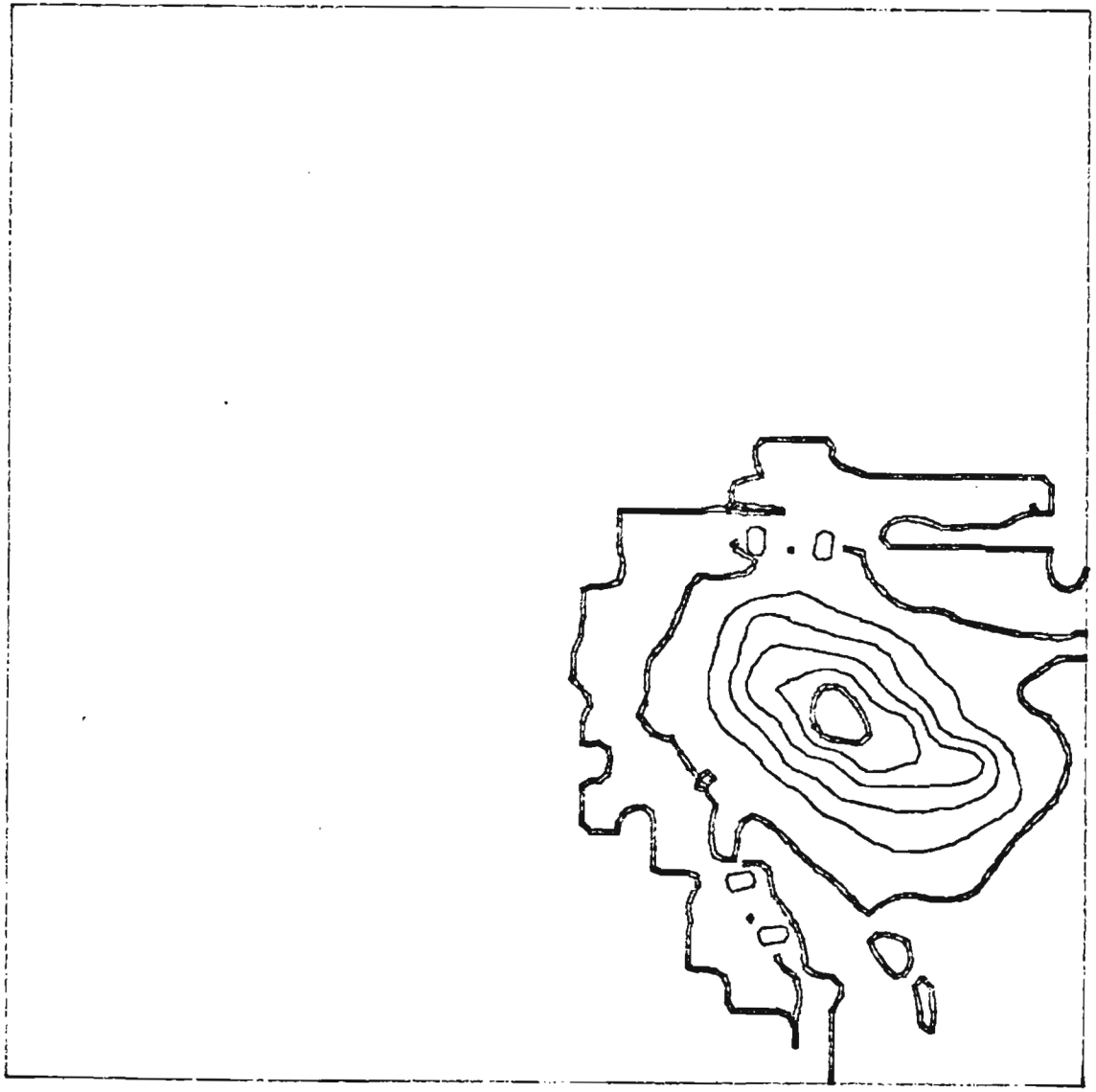


FIGURE 10

Facet 81, Cone @ 30 cm
Slope Error = 0
Power = 1.0929 kw
Contour Interval = 50

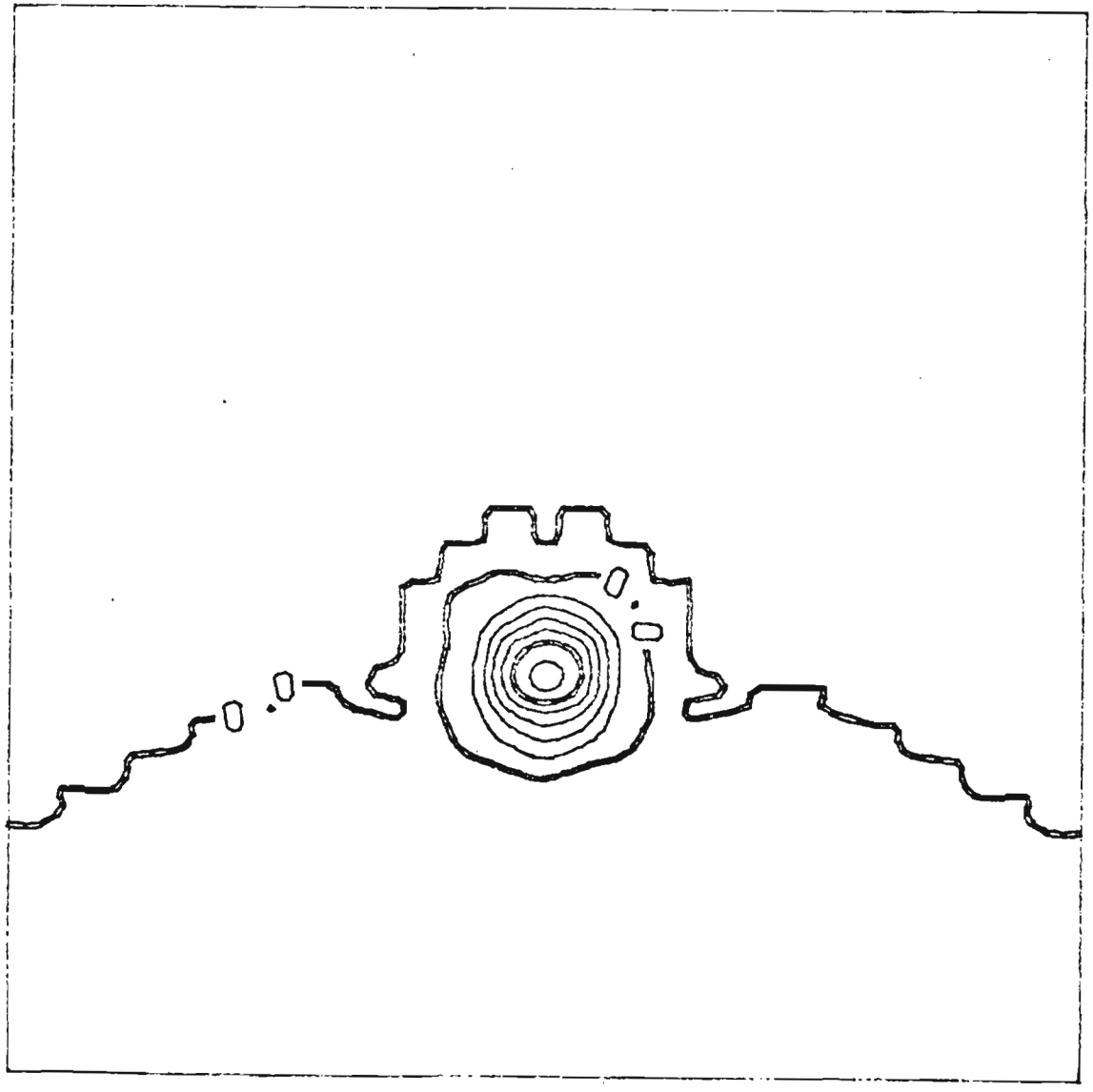


FIGURE 11

Facet 81, Cone @ 30 cm
Slope Error = 1.0 mRad.
Power = 1.0929 kw
Contour Interval = 50

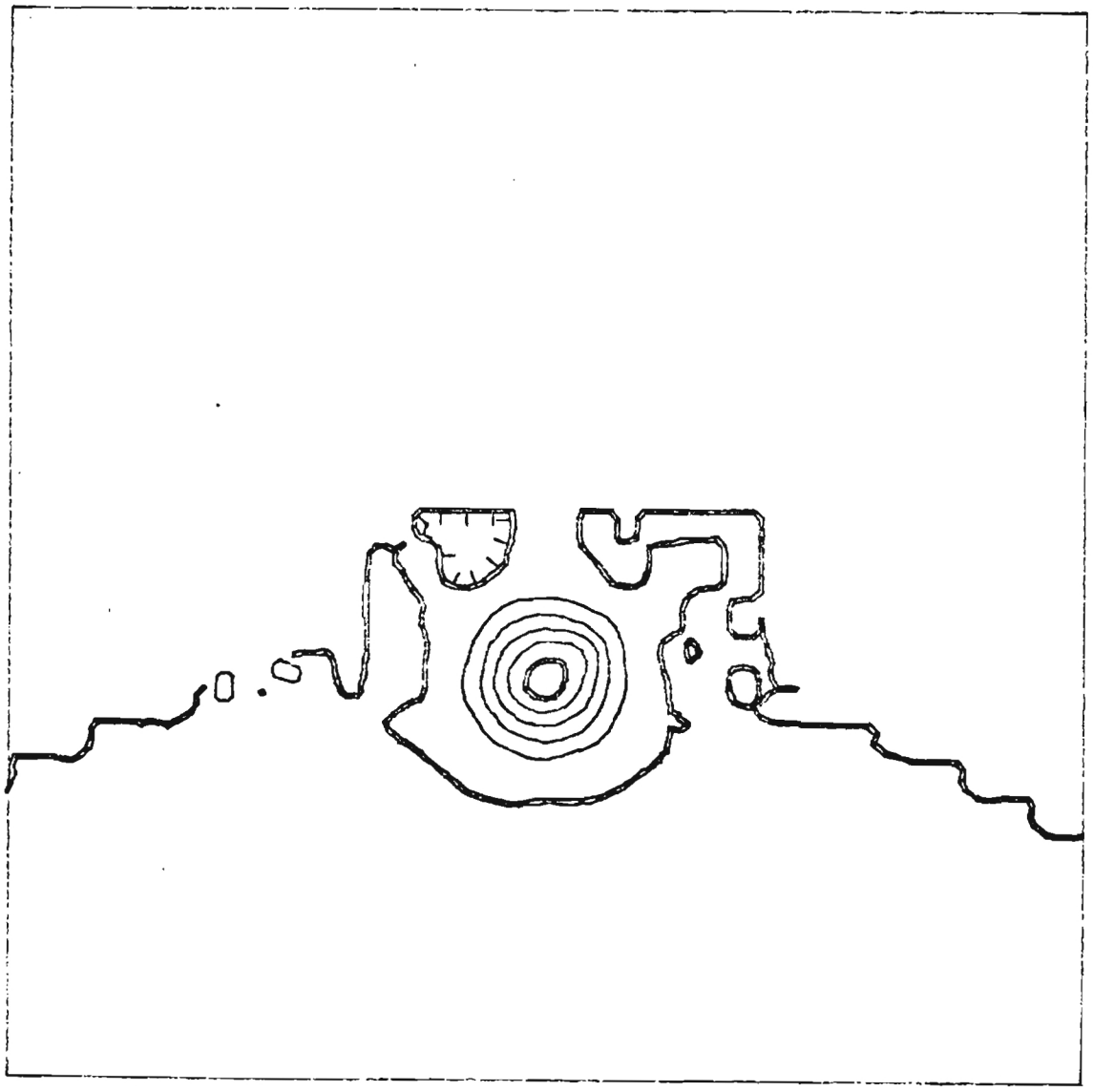


FIGURE 12

Facet 84, Cone @ 30 cm
Slope Error = 0
Power = 1.0255 kw
Contour Interval = 20

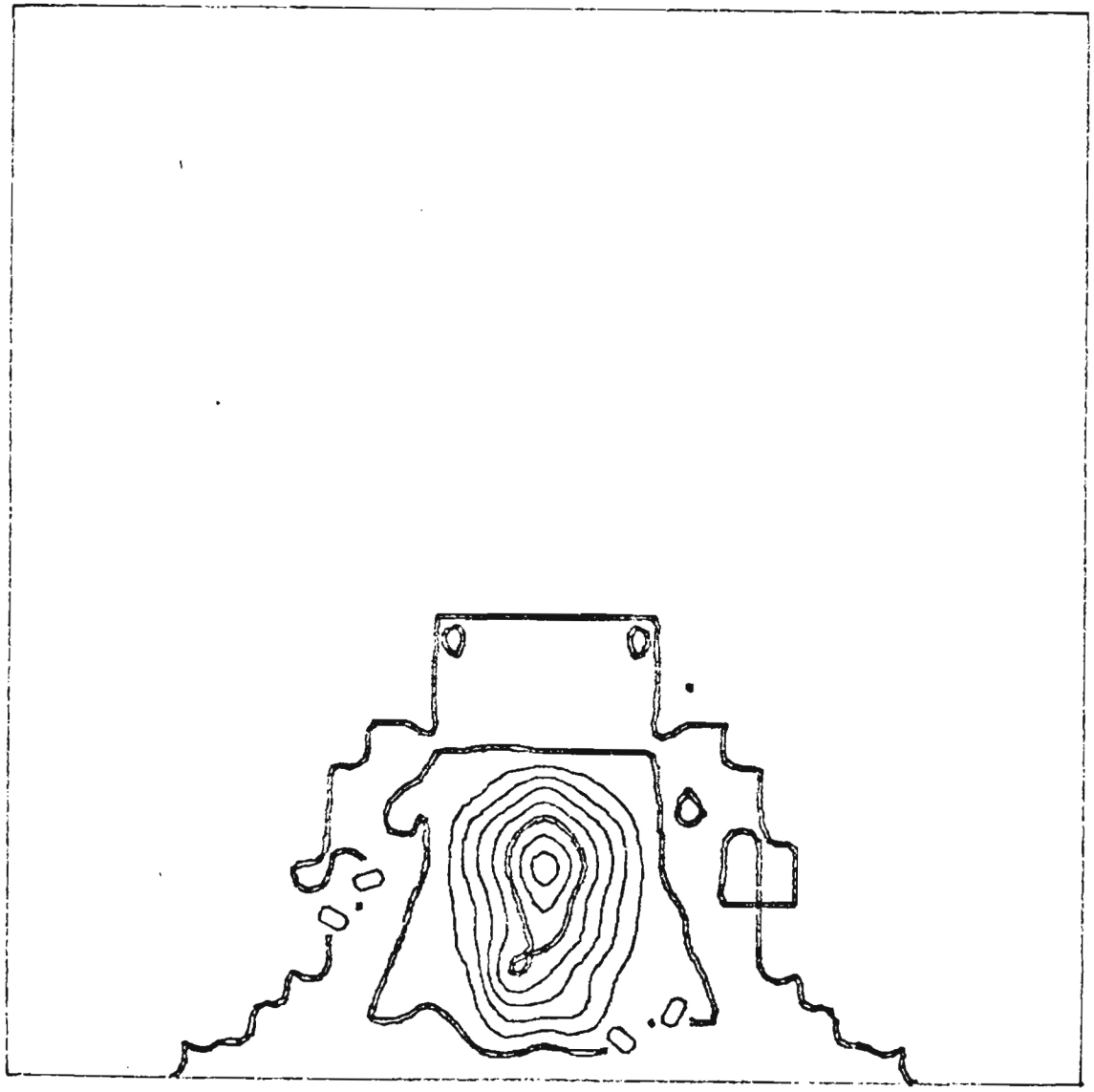


FIGURE 13

Facet 84, Cone @ 30 cm
Slope Error = 1.0 mRad
Power = 1.0255 kw
Contour Interval = 20

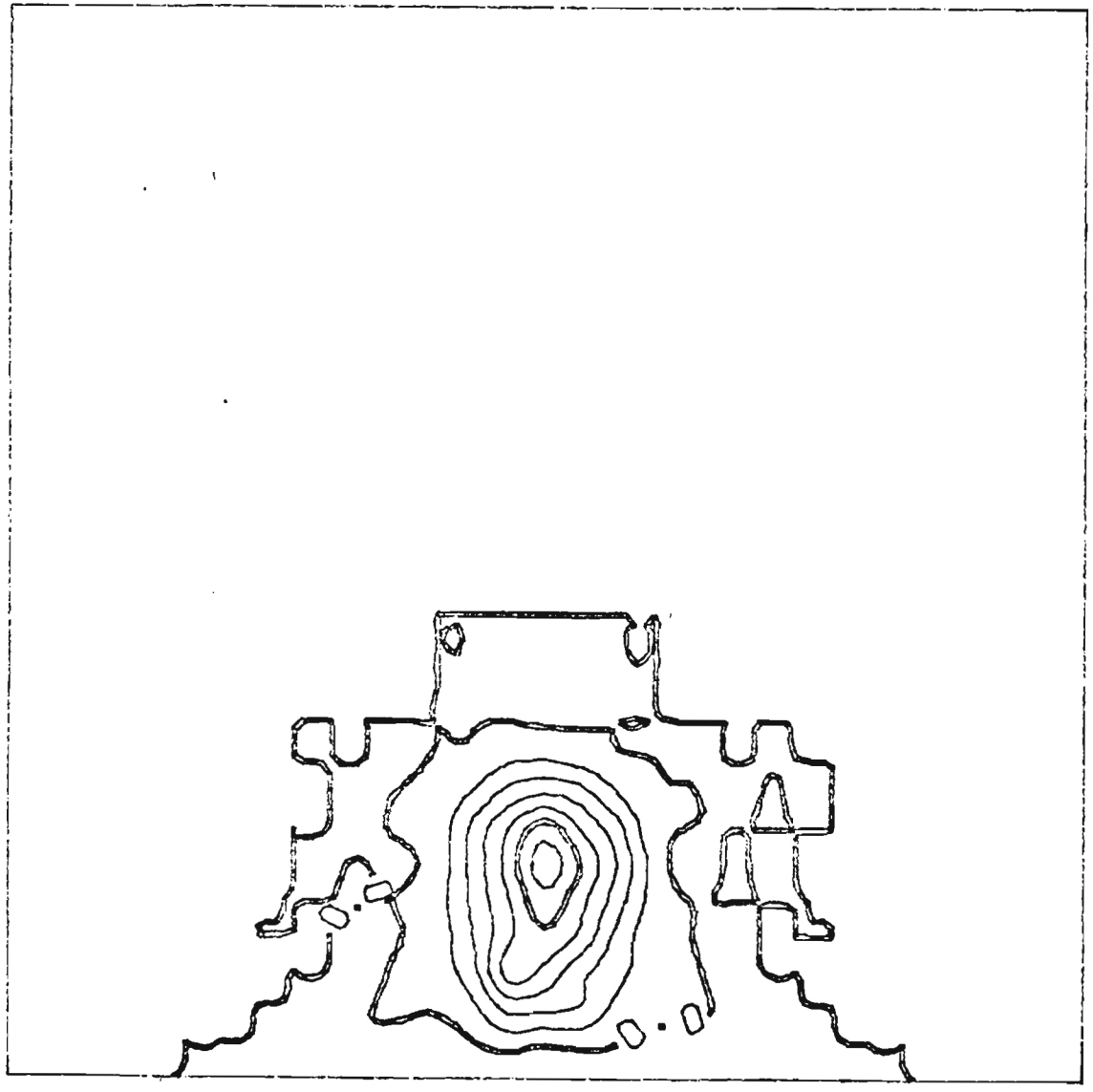


FIGURE 14

Facets 10, 81, 84, Focal Plane
Slope Error = 0
Power = 3.1413 kw
Peak Flux = 650.77
Contour Interval = 200

Flux Value at 90% Power:	47.46 KW/SQ M
Area Inside 90% Power Contour:	134.30 SQ CM
Power Inside 90% Power Contour:	2.79 KILOWATTS
90% Total Power (Check):	2.83 KILOWATTS

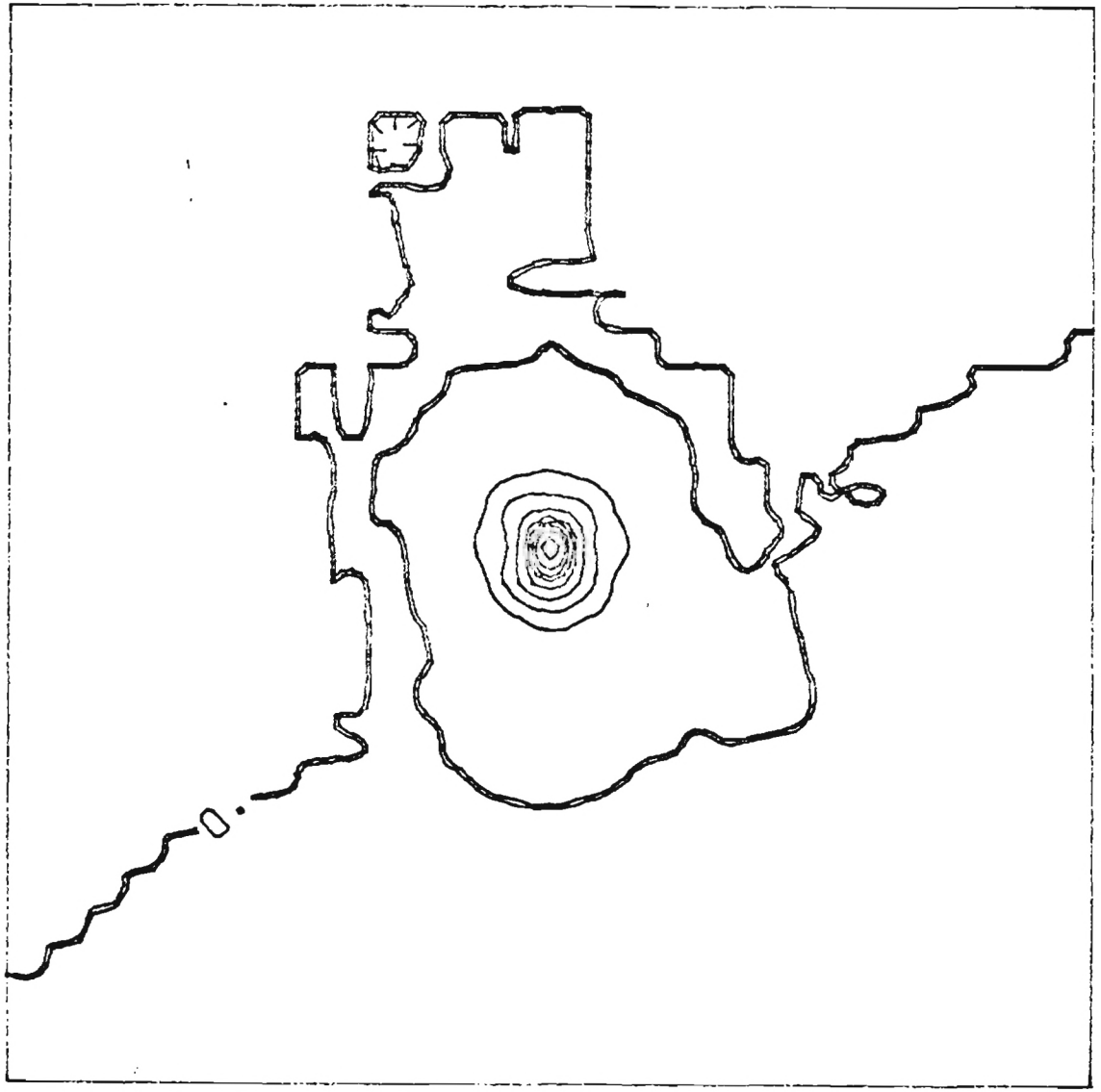


FIGURE 15

Facets 10, 81, 84, Focal Plane
Slope Error = 1.0 mRad.
Power = 3.1413 kw
Peak Flux = 565.88
Contour Interval = 400

Flux Value at 90% Power:	37.51 KW/SQ M
Area Inside 90% Power Contour:	165.20 SQ CM
Power Inside 90% Power Contour:	2.83 KILOWATTS
90% Total Power (Check):	2.83 KILOWATTS

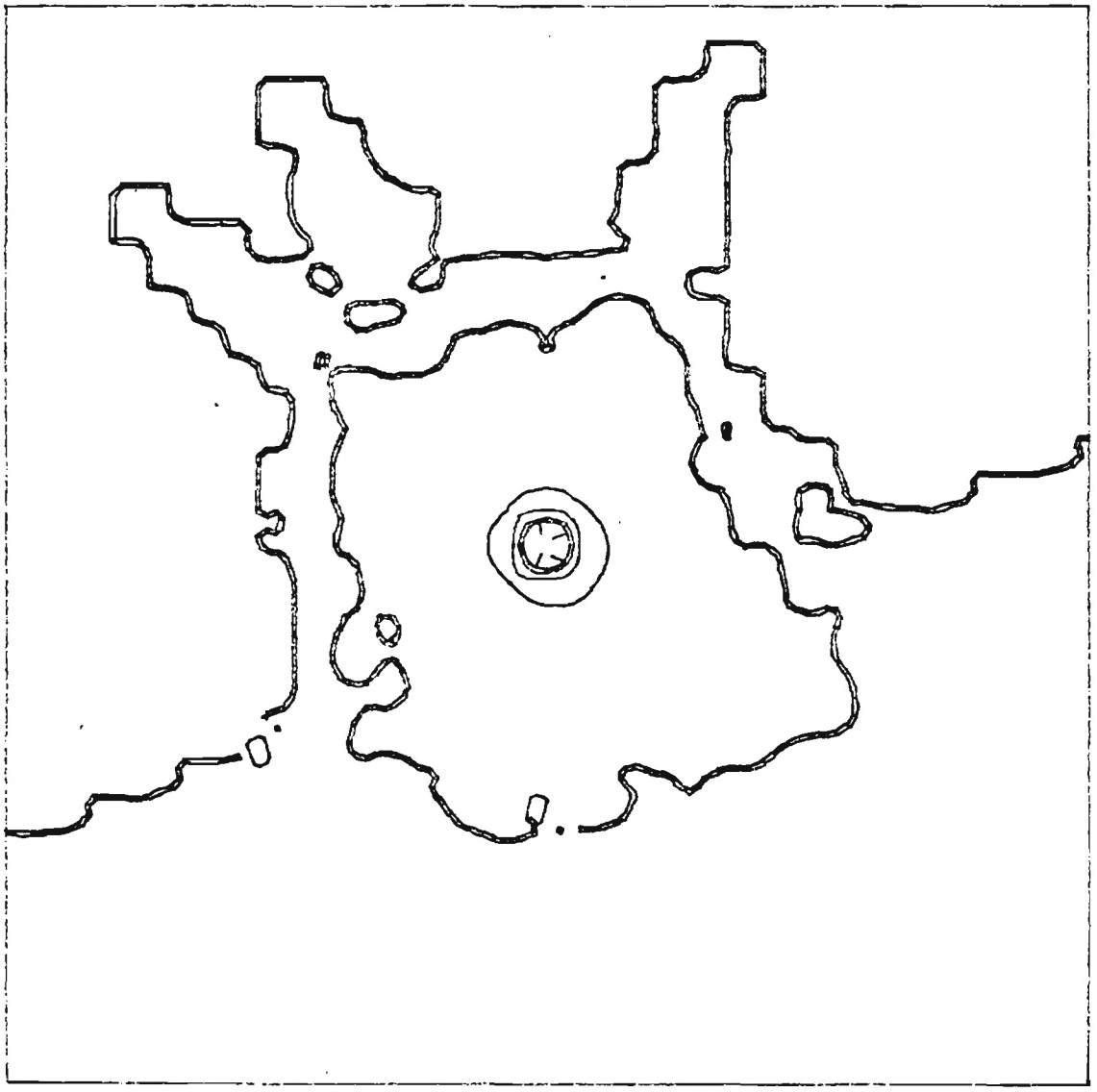


FIGURE 16

Facets 10, 81, 84, Cone @ 30 cm
Slope Error = 0
Power = 3.1413 kw
Contour Interval = 50

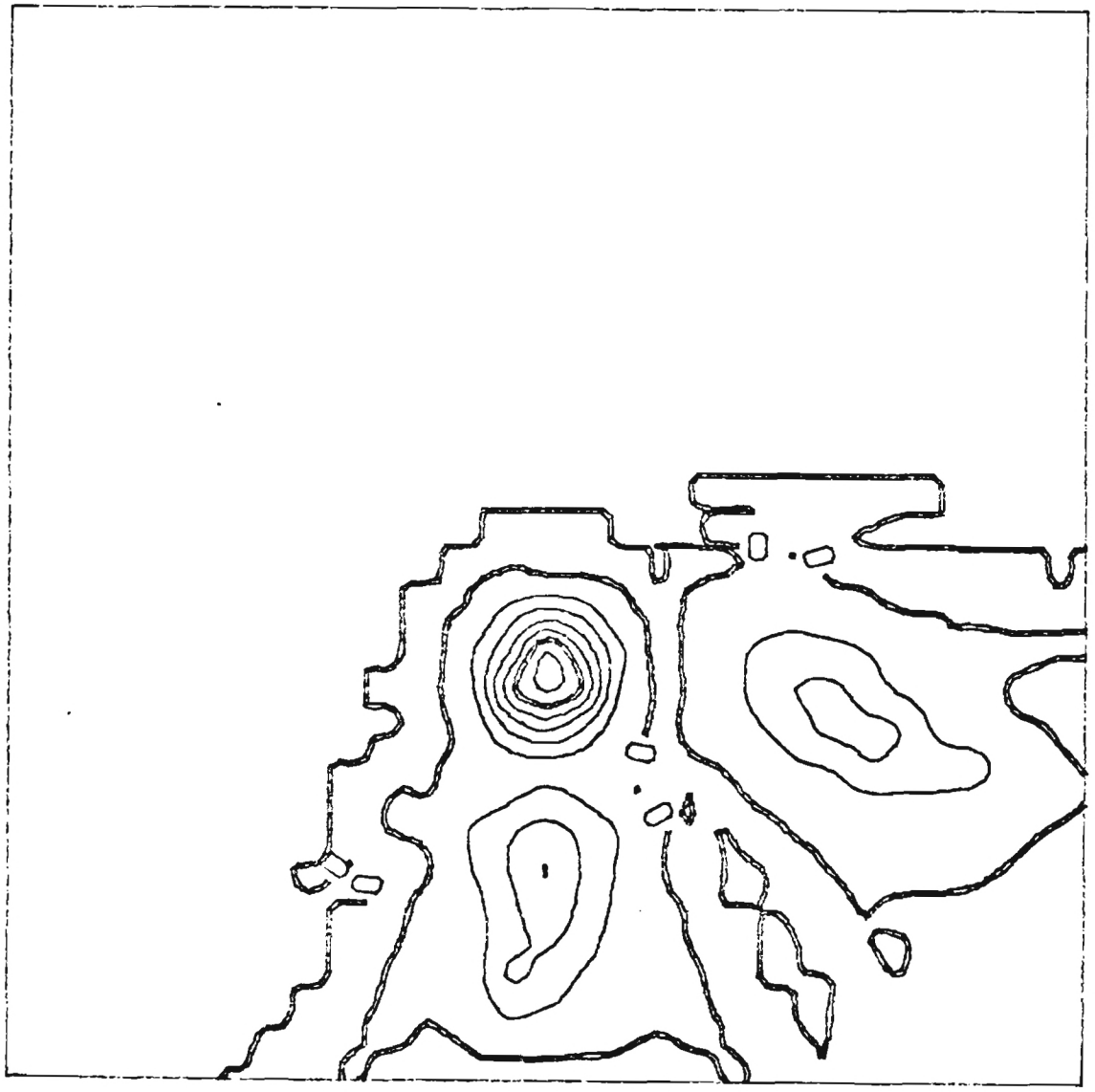


FIGURE 17

Facets 10, 81, 84, Cone @ 30 cm
Slope Error = 1.0 mRad.
Power = 3.1413 kw
Contour Interval = 20

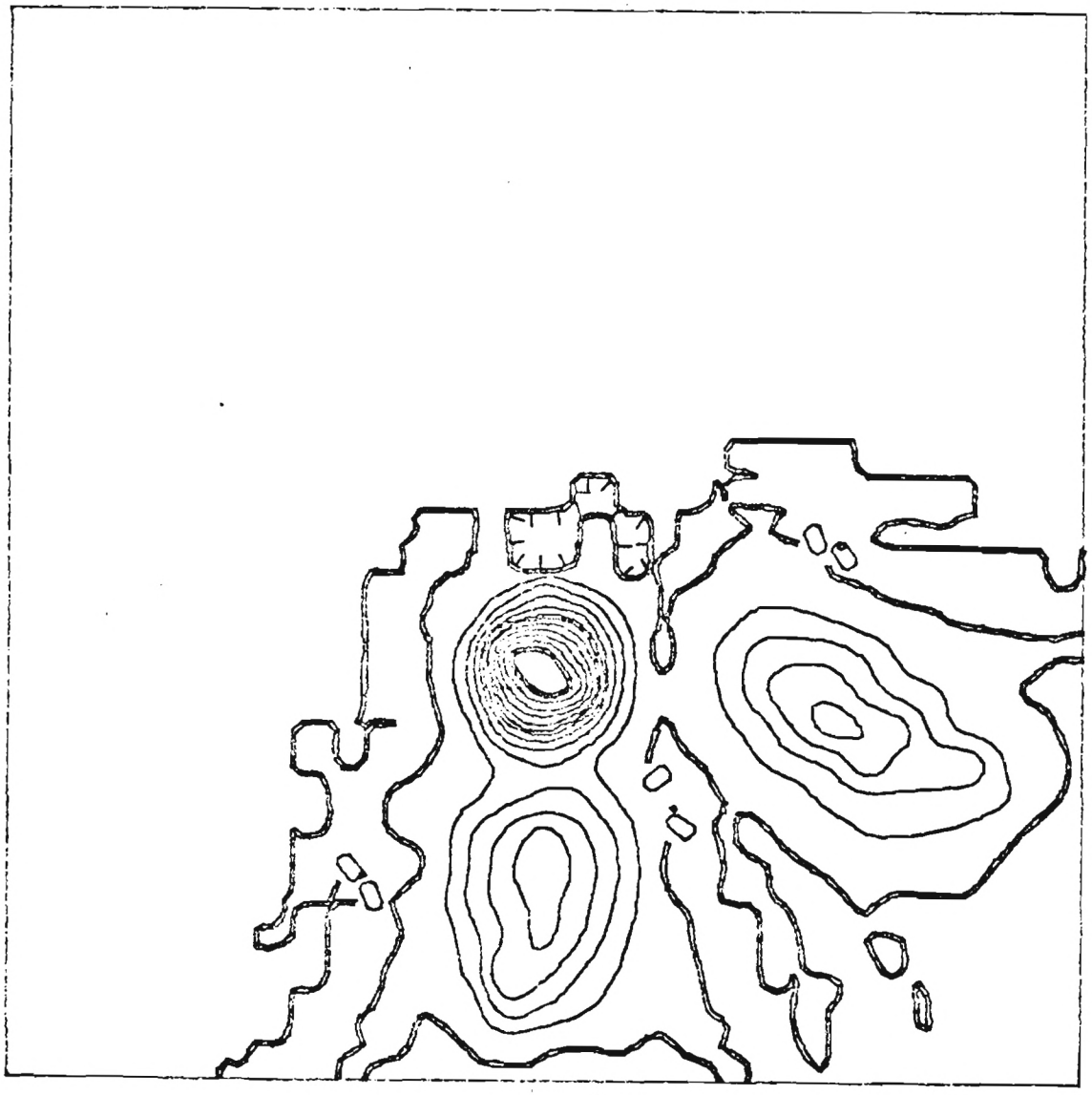


FIGURE 18

Curvature Test
Facet 10, Focal Plane
RC:Rad = 1:1
Slope Error = 0
Power = 1.0229 kw
Peak Flux = 127.32
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	20.23 KW/SQ M
Area Inside 90% Power Contour:	160.11 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

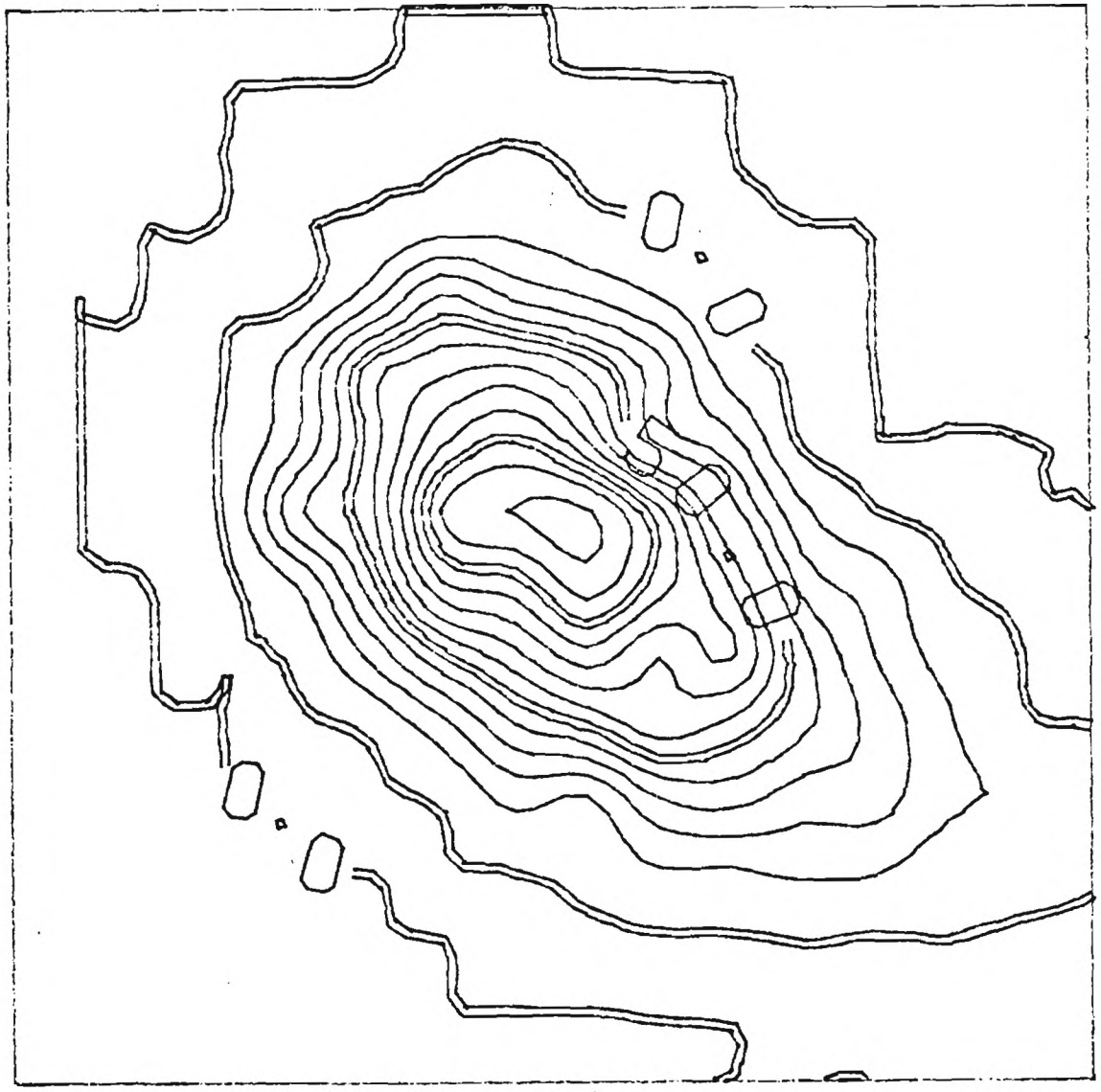


FIGURE 19

Curvature Test
Facet 10, Focal Plane
RC:Rad = 6:4
Slope Error = 0
Power = 1.0229 kw
Peak Flux = 113.18
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	19.49 KW/SQ M
Area Inside 90% Power Contour:	160.09 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

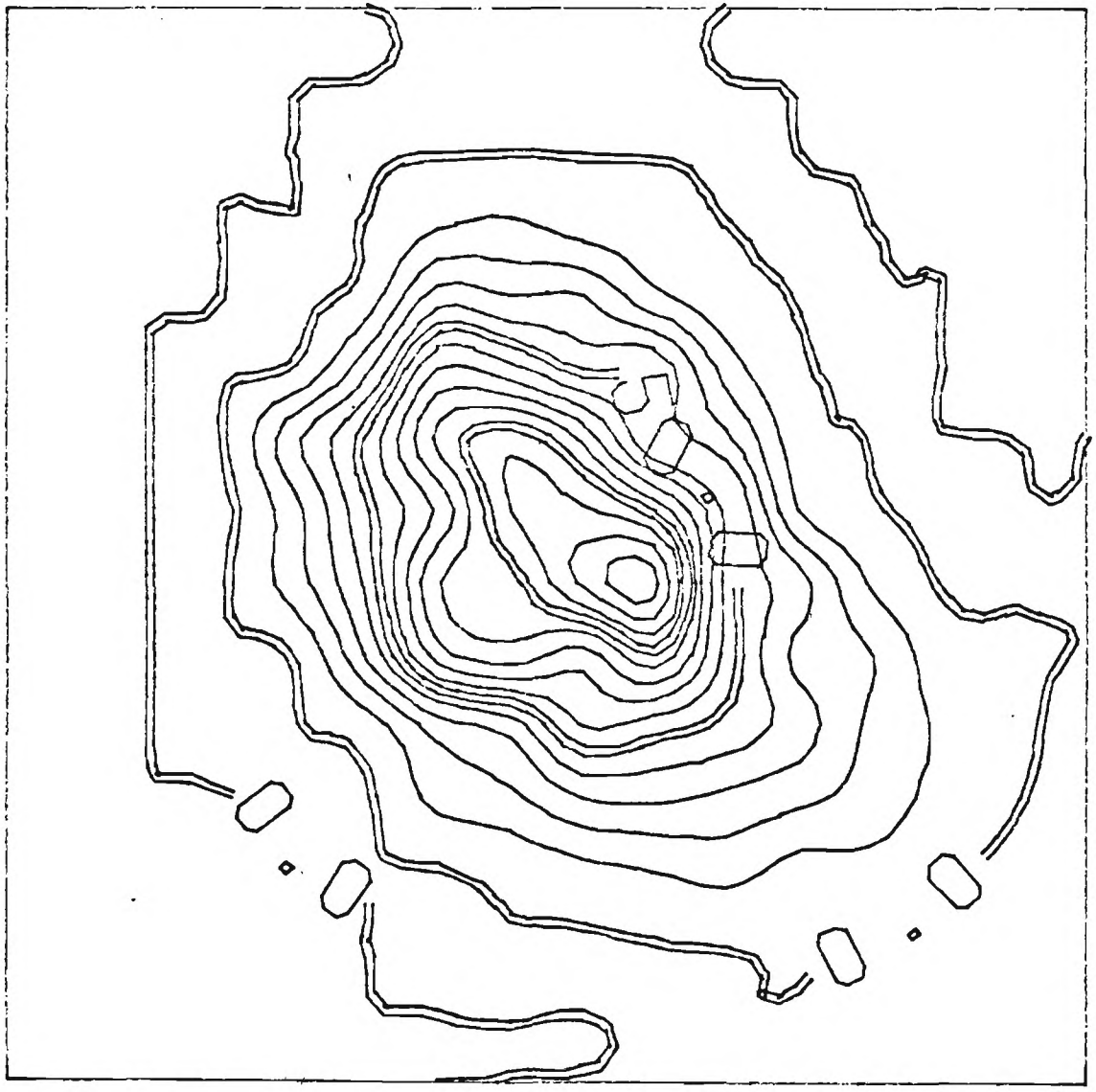


FIGURE 20

Curvature Test
Facet 10, Focal Plane
RC:Rad = 7:3
Slope Error = 1
Power = 1.0229 kw
Peak Flux = 113.18
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	20.27 KW/SQ M
Area Inside 90% Power Contour:	157.63 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

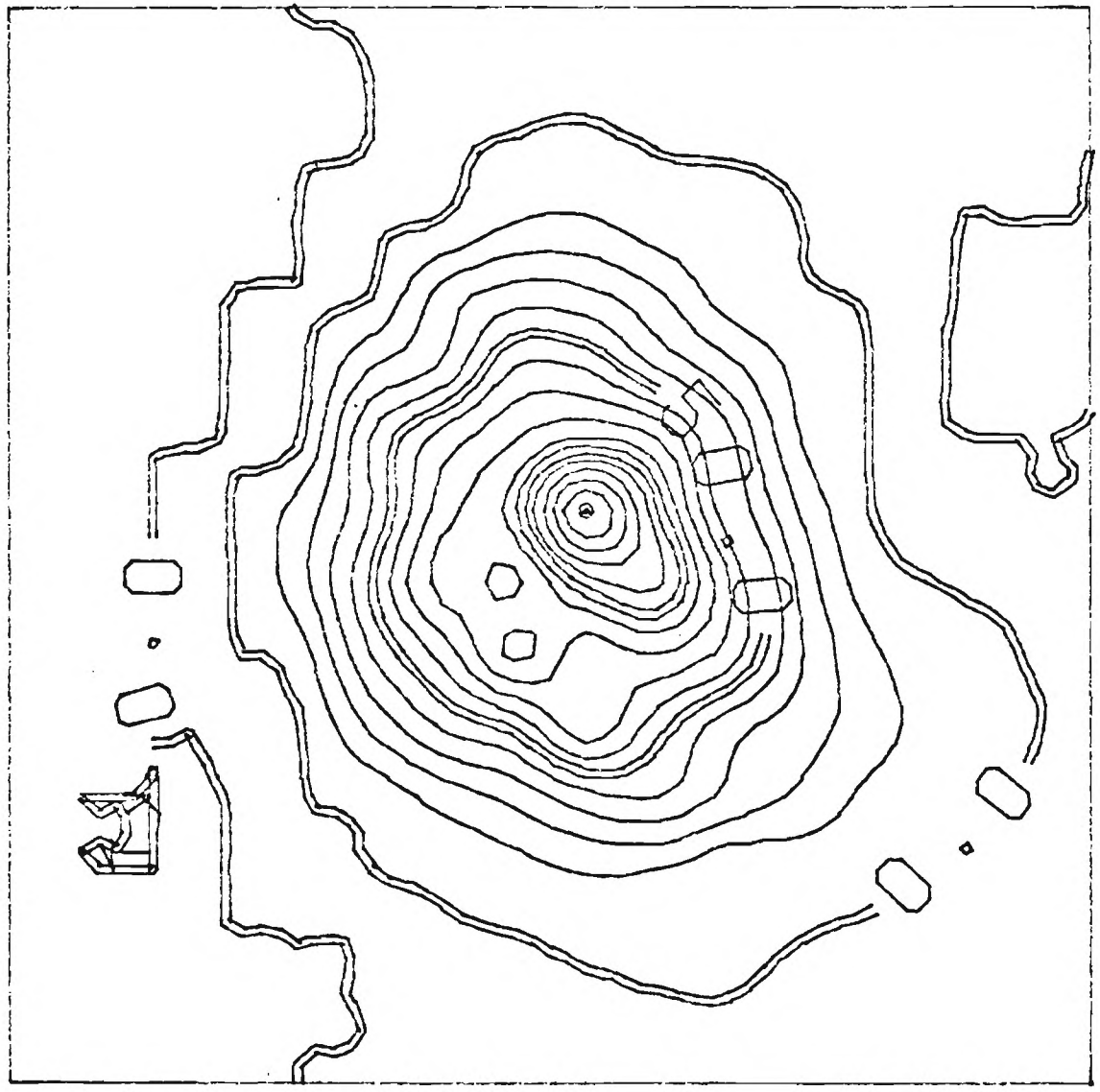


FIGURE 21

Curvature Test
Facet 10, Focal Plane
RC:Rad = 8:2
Slope Error = 0
Power = 1.0229 kw
Peak Flux = 113.18
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	19.41 KW/SQ M
Area Inside 90% Power Contour:	161.38 SQ CM
Power Inside 90% Power Contour:	.93 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

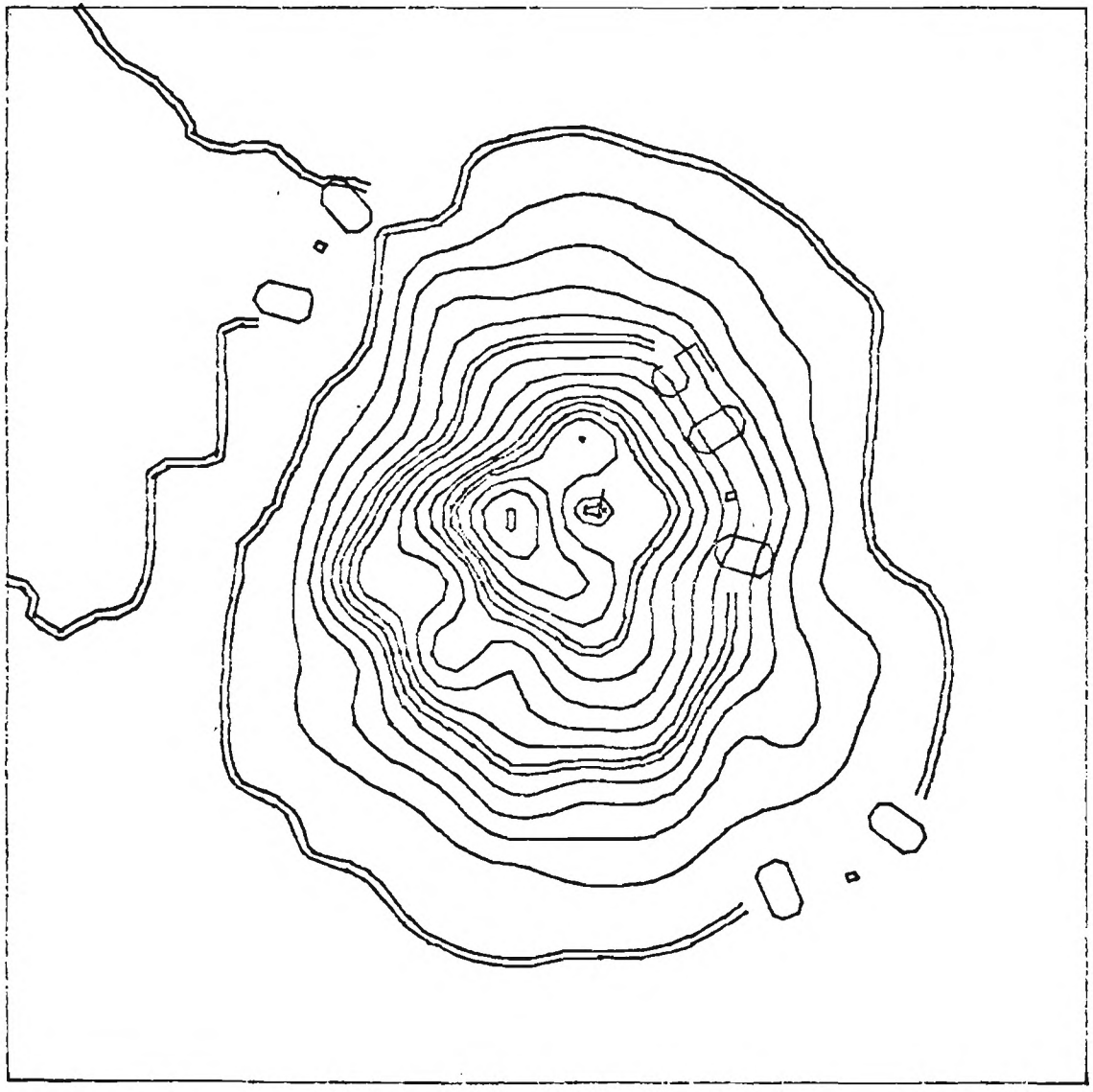


FIGURE 22

Curvature Test
Facet 81, Focal Plane
RC:Rad = 1:1
Slope Error = 0
Power = 1.0929 kw
Peak Flux = 410.27
Contour Interval = 50
(30 x 30 cm plot)

Flux Value at 90% Power:	184.44 KW/SQ M
Area Inside 90% Power Contour:	33.23 SQ CM
Power Inside 90% Power Contour:	.98 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

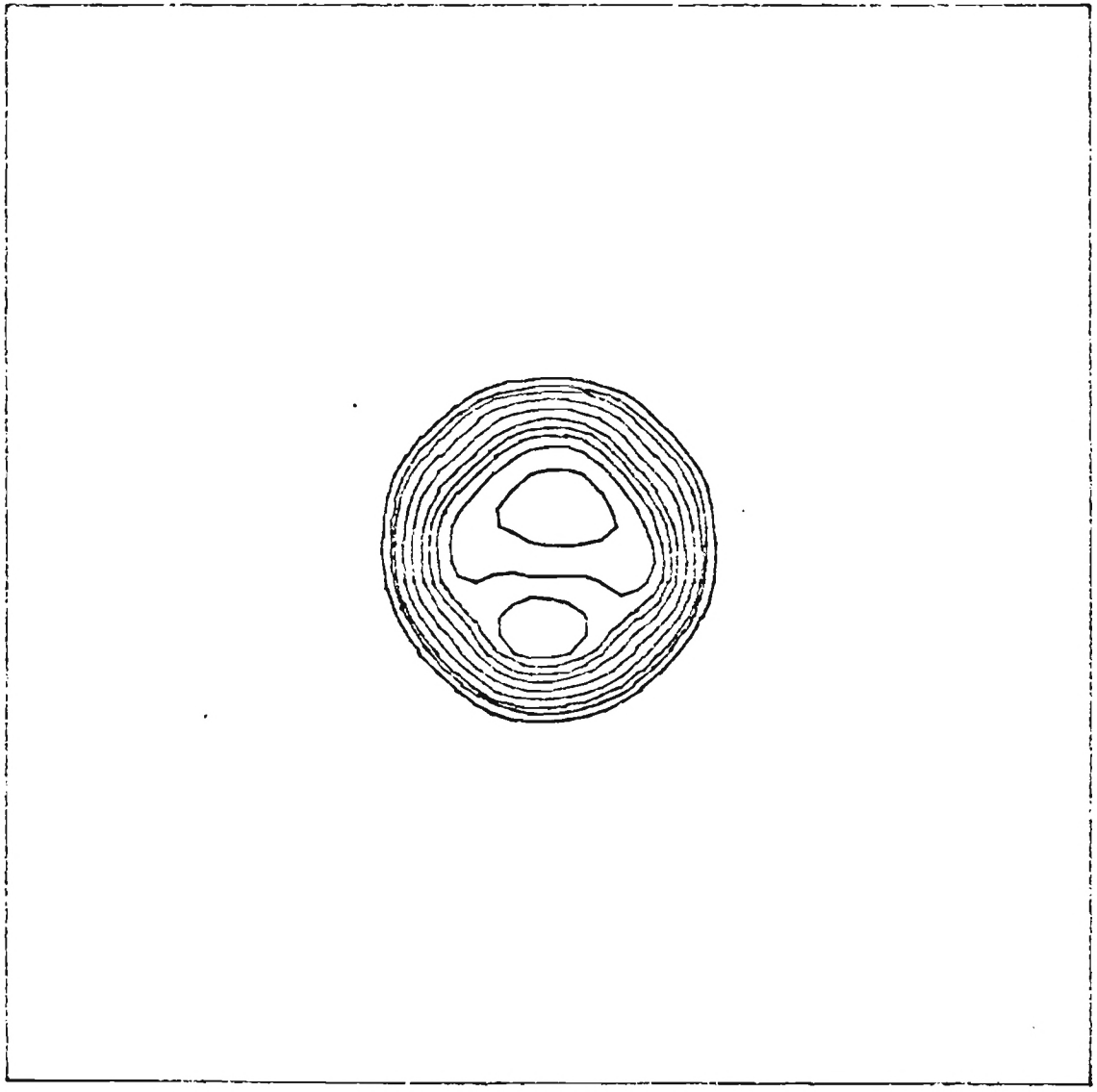


FIGURE 23

Curvature Test
Facet 81, Focal Plane
RC:Rad = 6:4
Slope Error = 0
Power = 1.0929 kw
Peak Flux = 396.11
Contour Interval = 50
(30 x 30 cm plot)

Flux Value at 90% Power:	177.03 KW/SQ M
Area Inside 90% Power Contour:	32.99 SQ CM
Power Inside 90% Power Contour:	.99 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

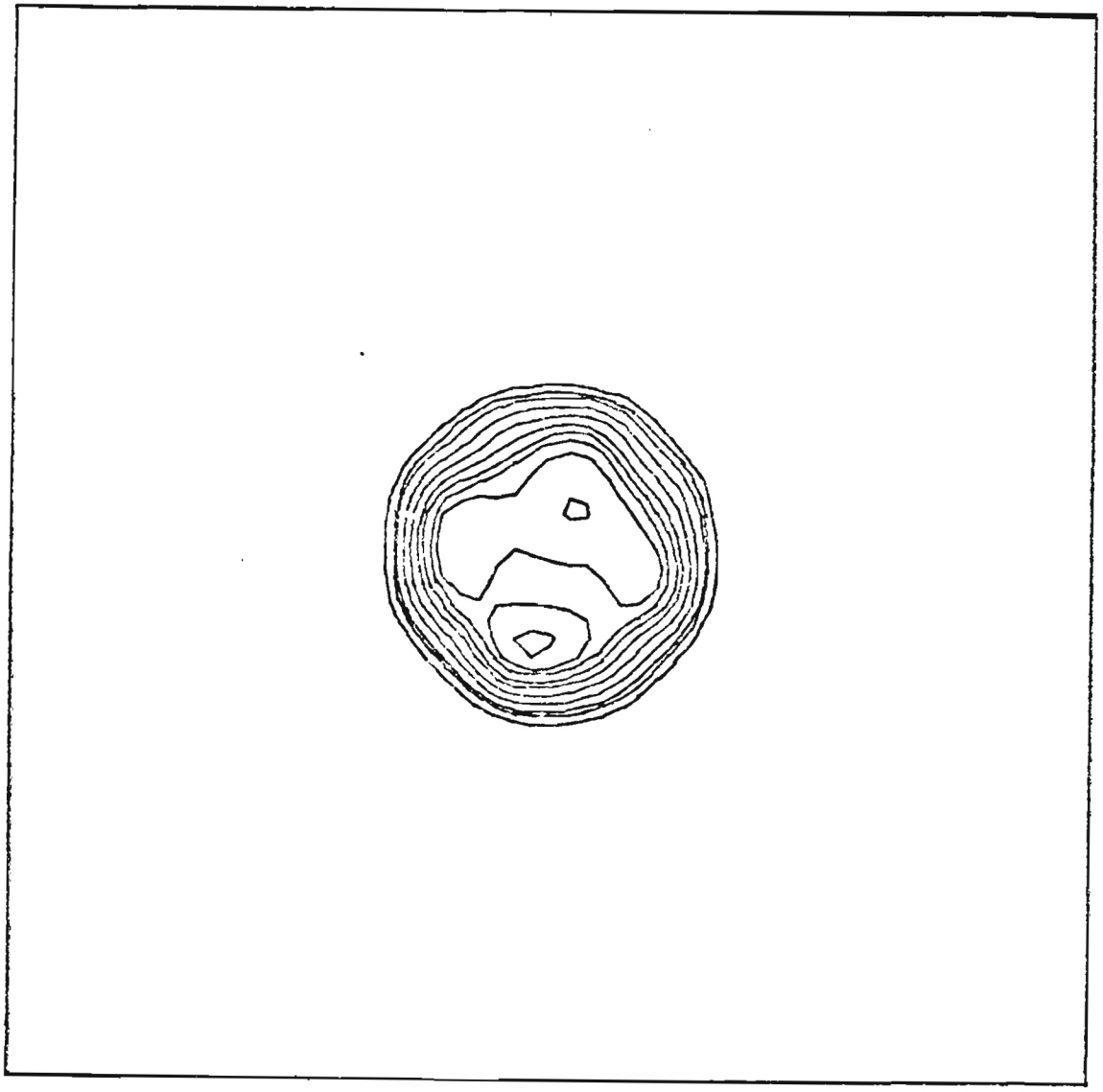


FIGURE 24

Curvature Test
Facet 81, Focal Plane
RC:Rad = 7:3
Slope Error = 0
Power = 1.0929 kw
Peak Flux = 410.27
Contour Interval = 50
(30 x 30 cm plot)

Flux Value at 90% Power:	188.92 KW/SQ M
Area Inside 90% Power Contour:	33.90 SQ CM
Power Inside 90% Power Contour:	1.00 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

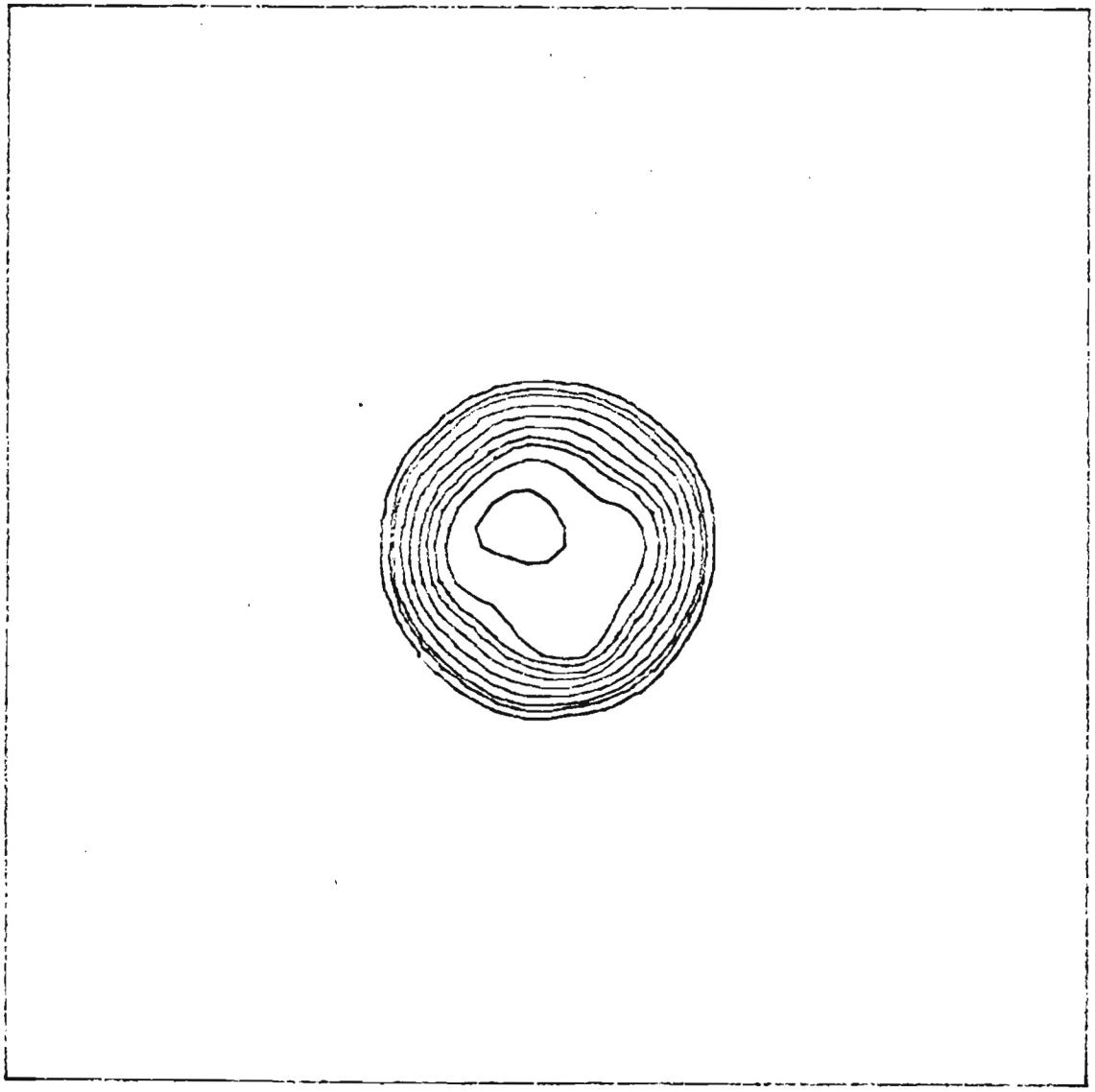


FIGURE 25

Curvature Test
Facet 81, Focal Plane
RC:Rad = 8:2
Slope Error = 0
Power = 1.0929 kw
Peak Flux = 396.12
Contour Interval = 50
(30 x 30 cm plot)

Flux Value at 90% Power:	182.86 KW/SQ M
Area Inside 90% Power Contour:	33.47 SQ CM
Power Inside 90% Power Contour:	.99 KILOWATTS
90% Total Power (Check):	.98 KILOWATTS

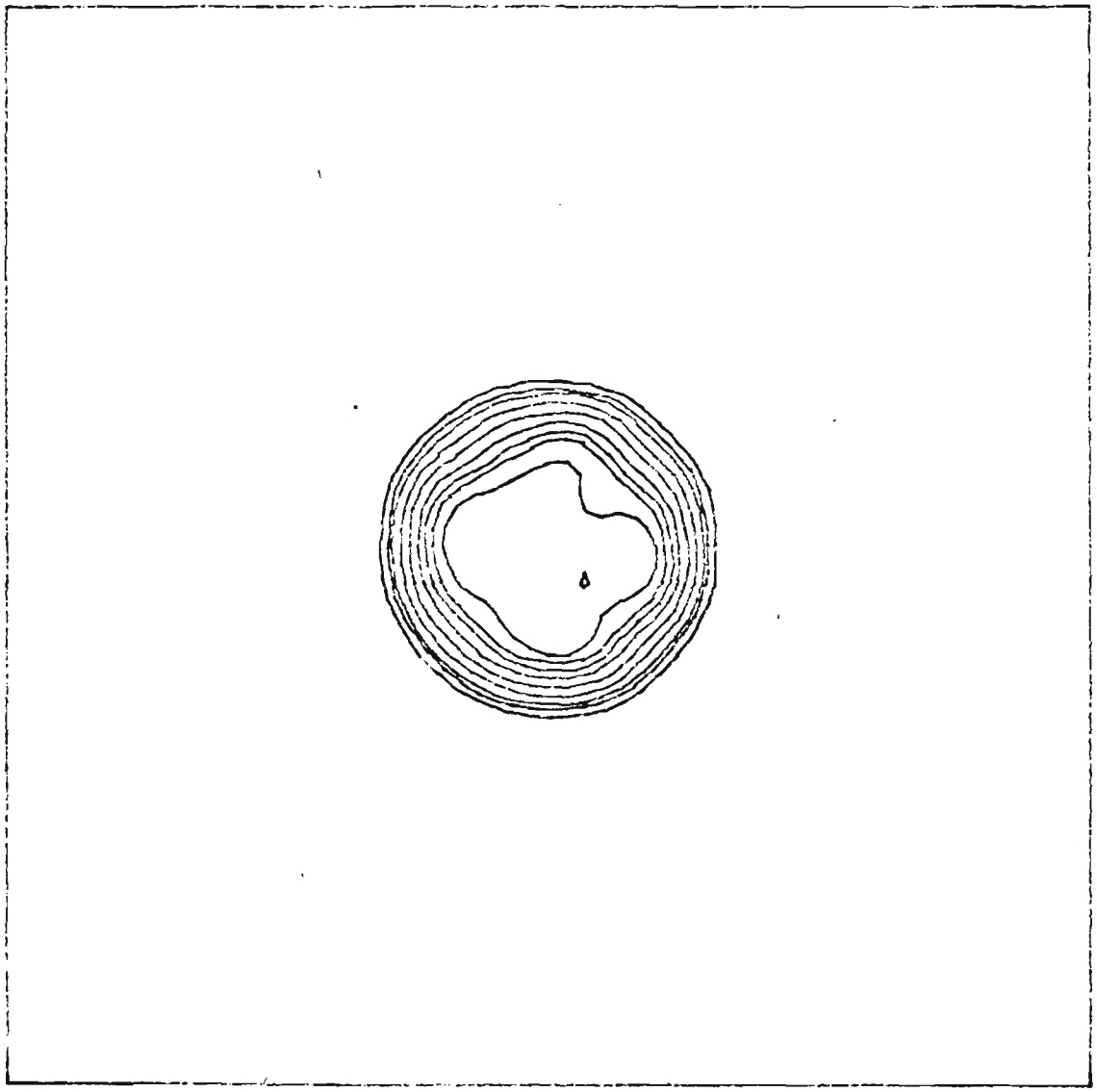


FIGURE 26

Curvature Test
Facet 84, Focal Plane
RC:Rad = 1:1
Slope Error = 0
Power = 1.0255 kw
Peak Flux = 127.32
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	22.07 KW/SQ M
Area Inside 90% Power Contour:	143.79 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

FIGURE 27

Curvature Test
Facet 84, Focal Plane
RC:Rad = 6:4
Slope Error = 0
Power = 1.0255 kw
Peak Flux = 141.47
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	23.69 KW/SQ M
Area Inside 90% Power Contour:	141.46 SQ CM
Power Inside 90% Power Contour:	.93 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

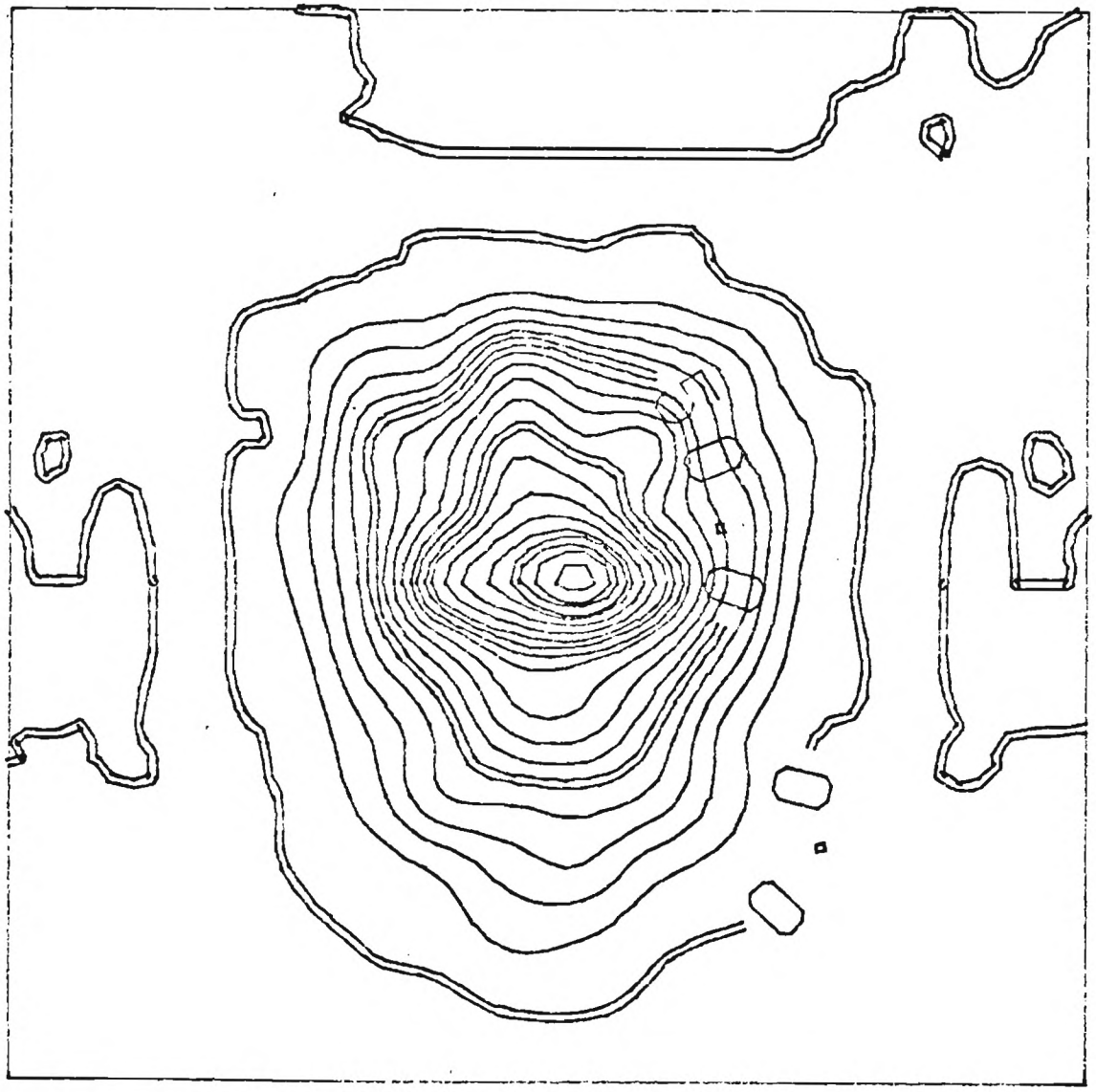


FIGURE 28

Curvature Test
Facet 84, Focal Plane
RC:Rad = 7:3
Slope Error = 0
Power = 1.0255 kw
Peak Flux = 127.32
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	24.36 KW/SQ M
Area Inside 90% Power Contour:	136.33 SQ CM
Power Inside 90% Power Contour:	.93 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

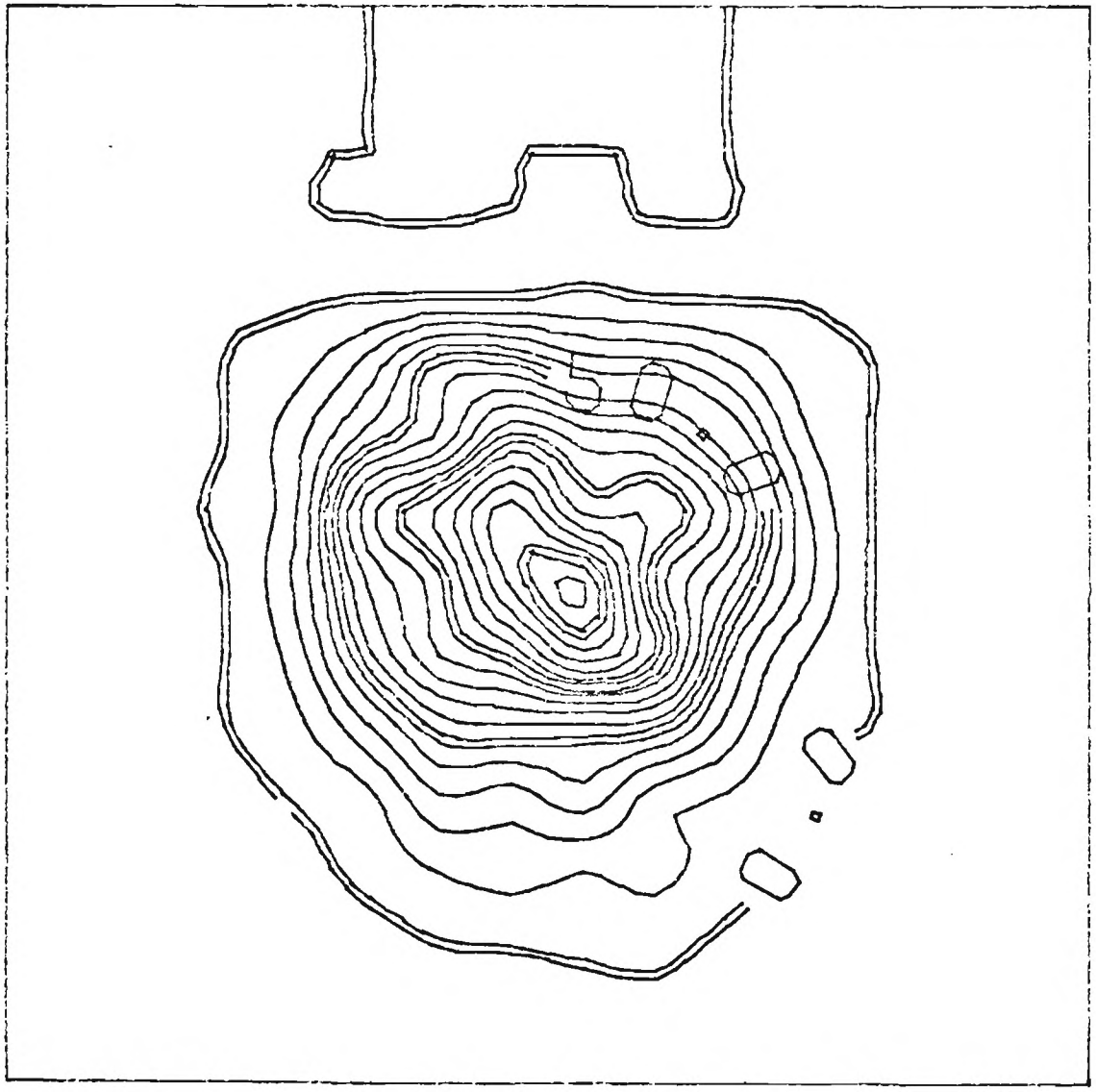


FIGURE 29

Curvature Test
Facet 84, Focal Plane
RC:Rad = 8:2
Slope Error = 0
Power = 1.0255 kw
Peak Flux = 127.32
Contour Interval = 10
(30 x 30 cm plot)

Flux Value at 90% Power:	25.35 KW/SQ M
Area Inside 90% Power Contour:	127.89 SQ CM
Power Inside 90% Power Contour:	.92 KILOWATTS
90% Total Power (Check):	.92 KILOWATTS

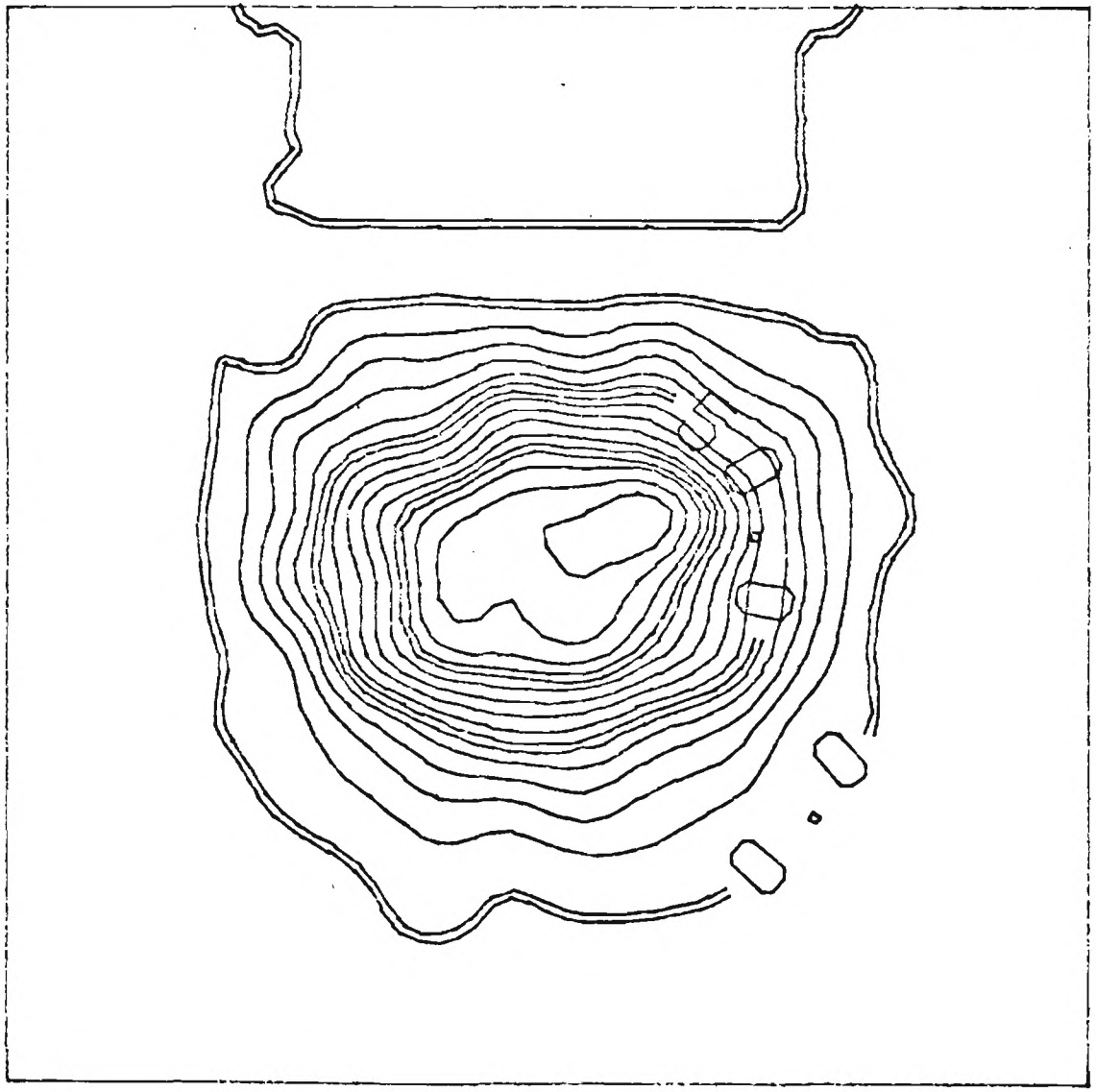


FIGURE 30

Curvature Test
Facet 10, Cone @ 30 cm
RC:Rad = 1:1
Slope Error = 0
Power = 1.0229 kw
Contour Interval = 20

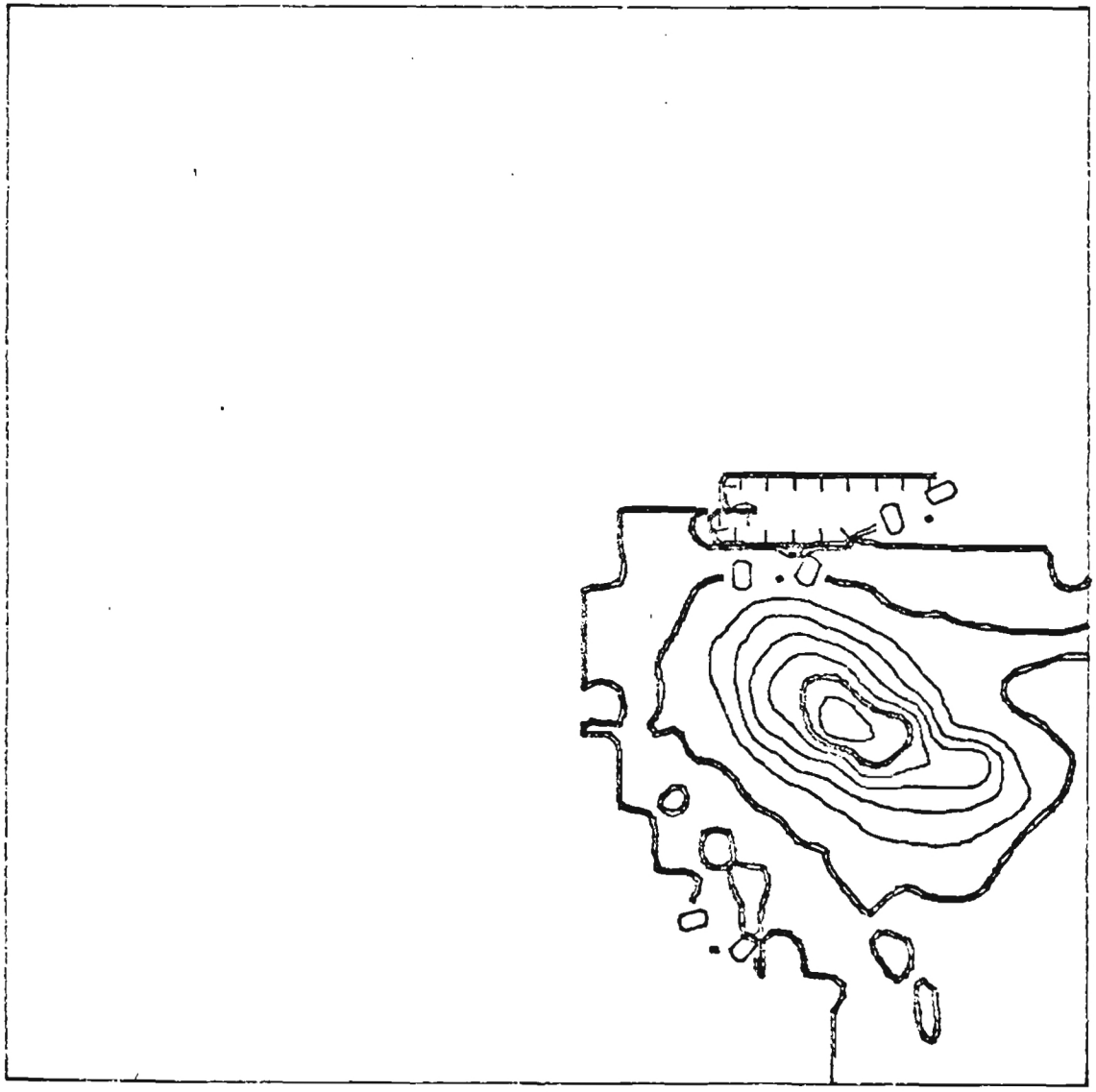


FIGURE 31

Curvature Test
Facet 10, Cone @ 30 cm
RC:Rad = 6:4
Slope Error = 0
Power = 1.0229 kw
Contour Interval = 20

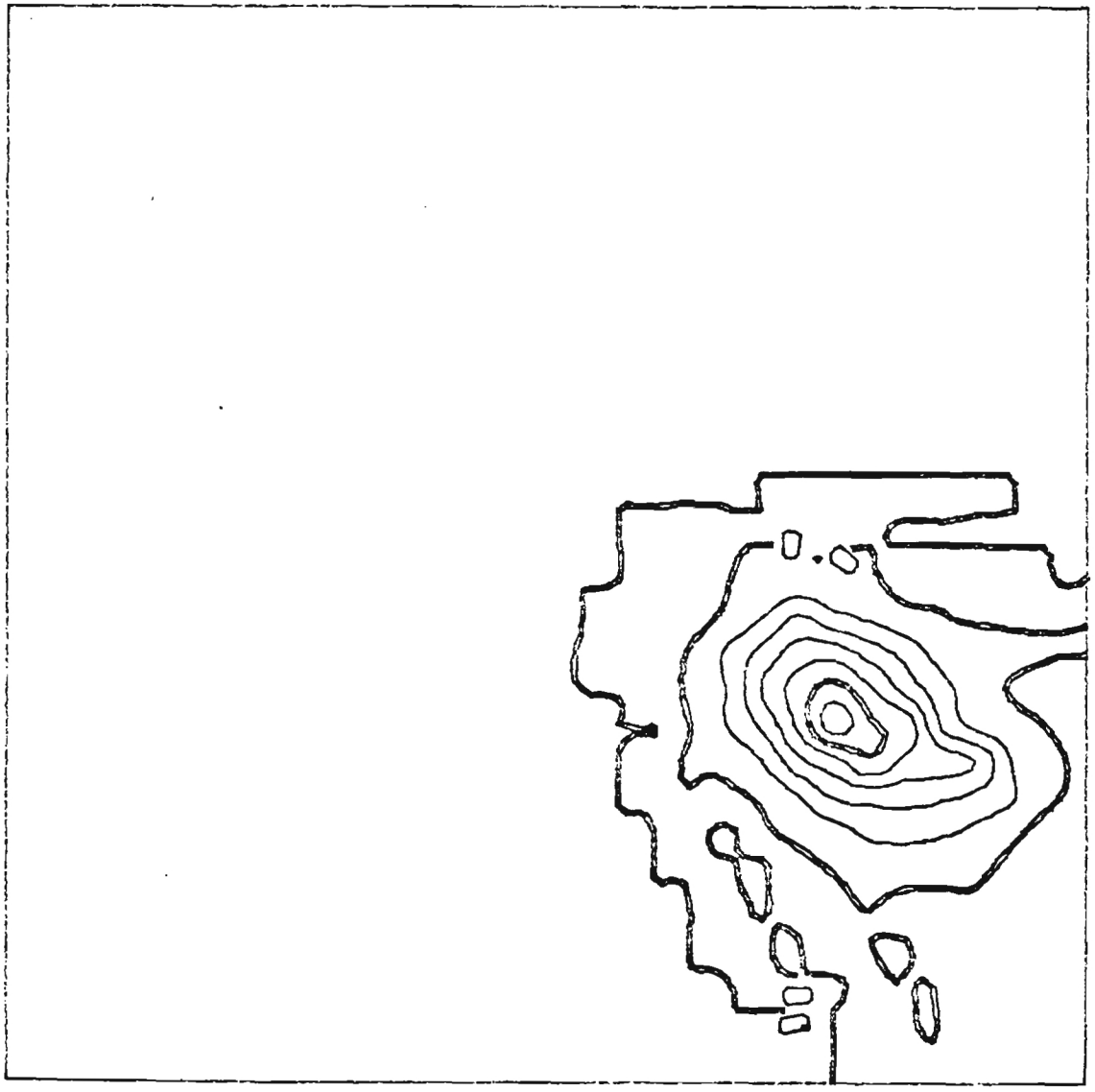


FIGURE 32

Curvature Test
Facet 10, Cone @ 30 cm
RC:Rad = 7:3
Slope Error = 0
Power = 1.0229 kw
Contour Interval = 20

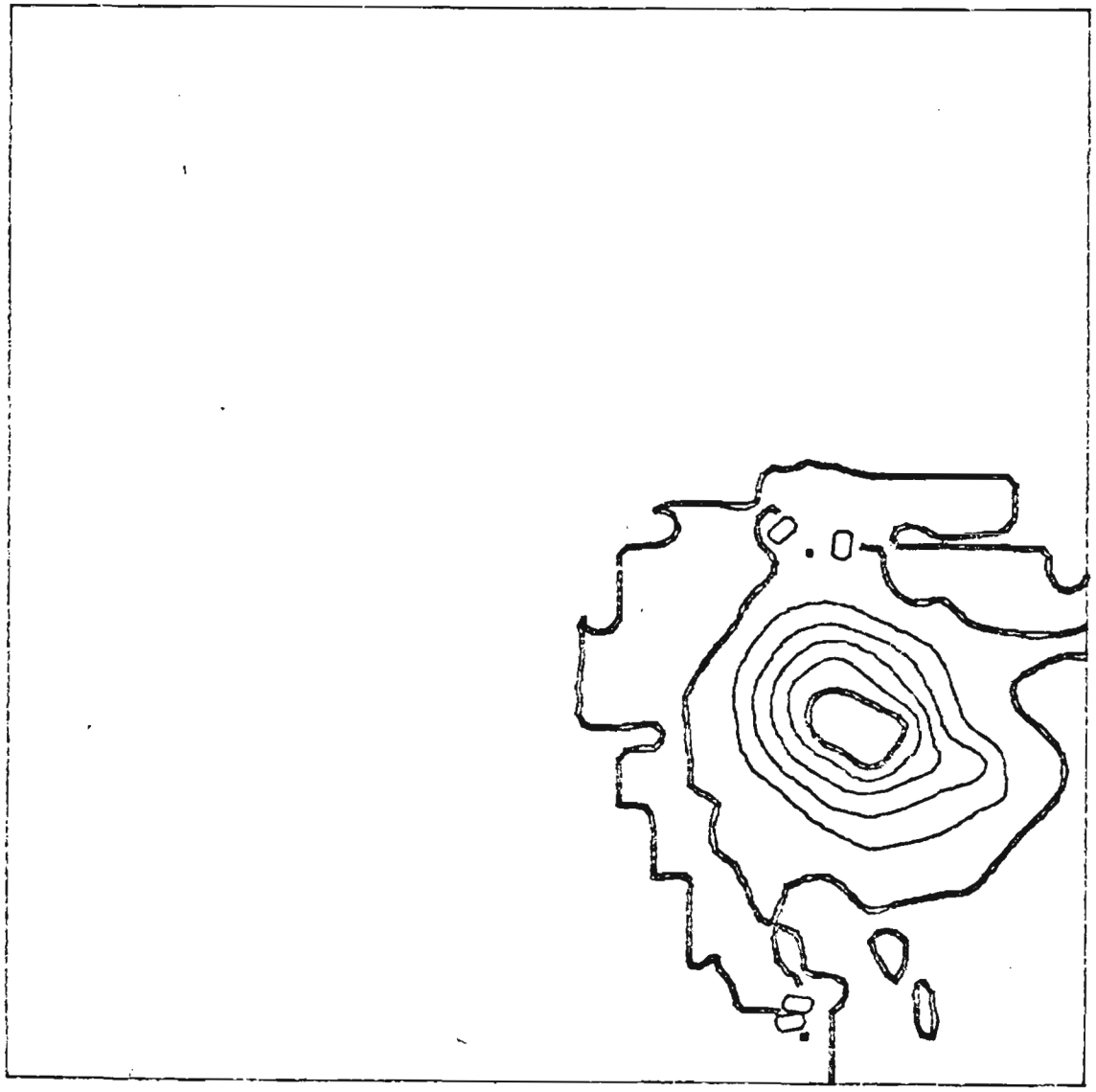


FIGURE 33

Curvature Test
Facet 10, Cone @ 30 cm
RC:Rad = 8:2
Slope Error = 0
Power = 1.0229 kw
Contour Interval = 20

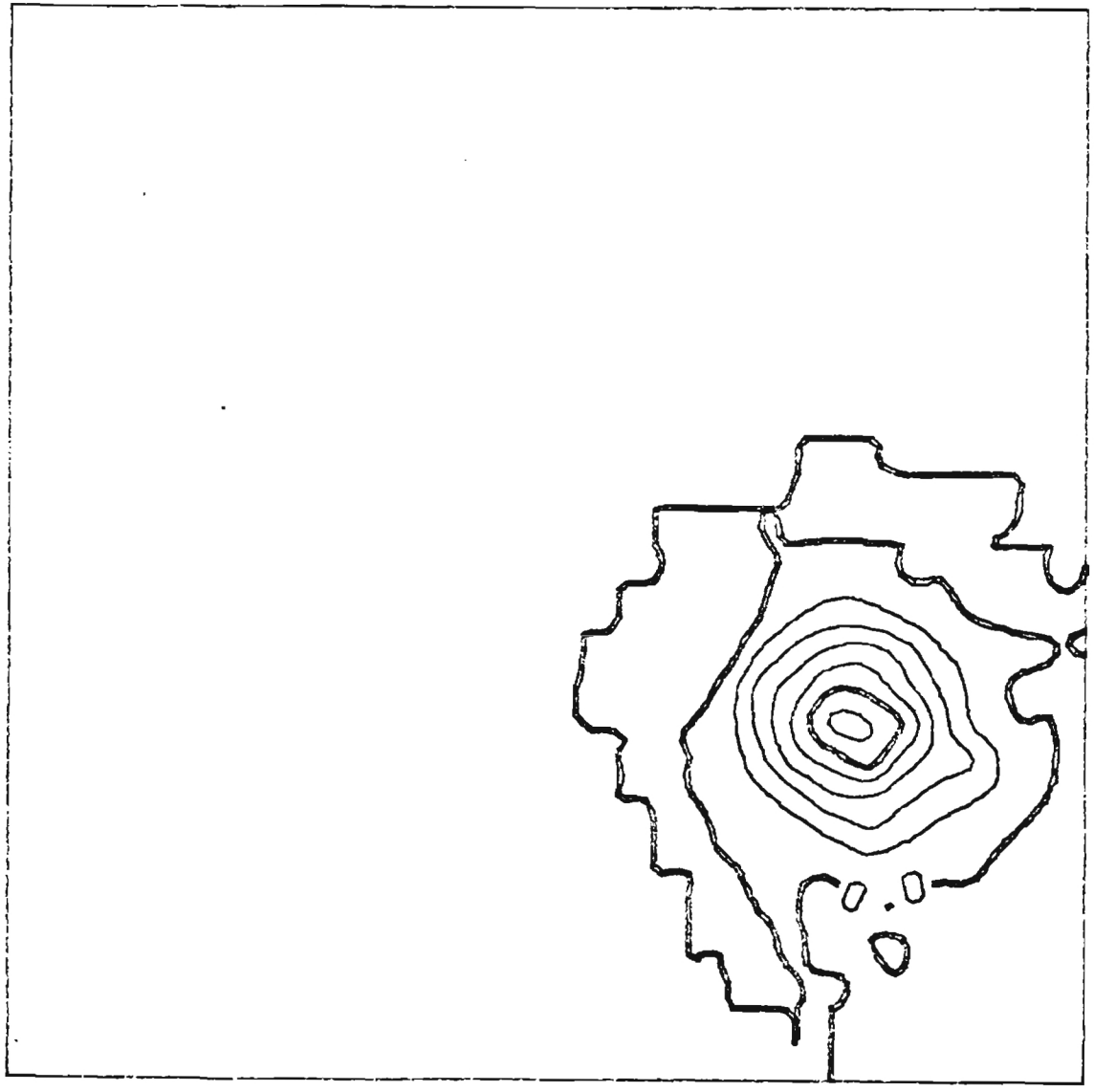


FIGURE 34

Curvature Test
Facet 81, Cone @ 30 cm
RC:Rad = 1:1
Slope Error = 0
Power = 1.0929 kw
Contour Interval = 50

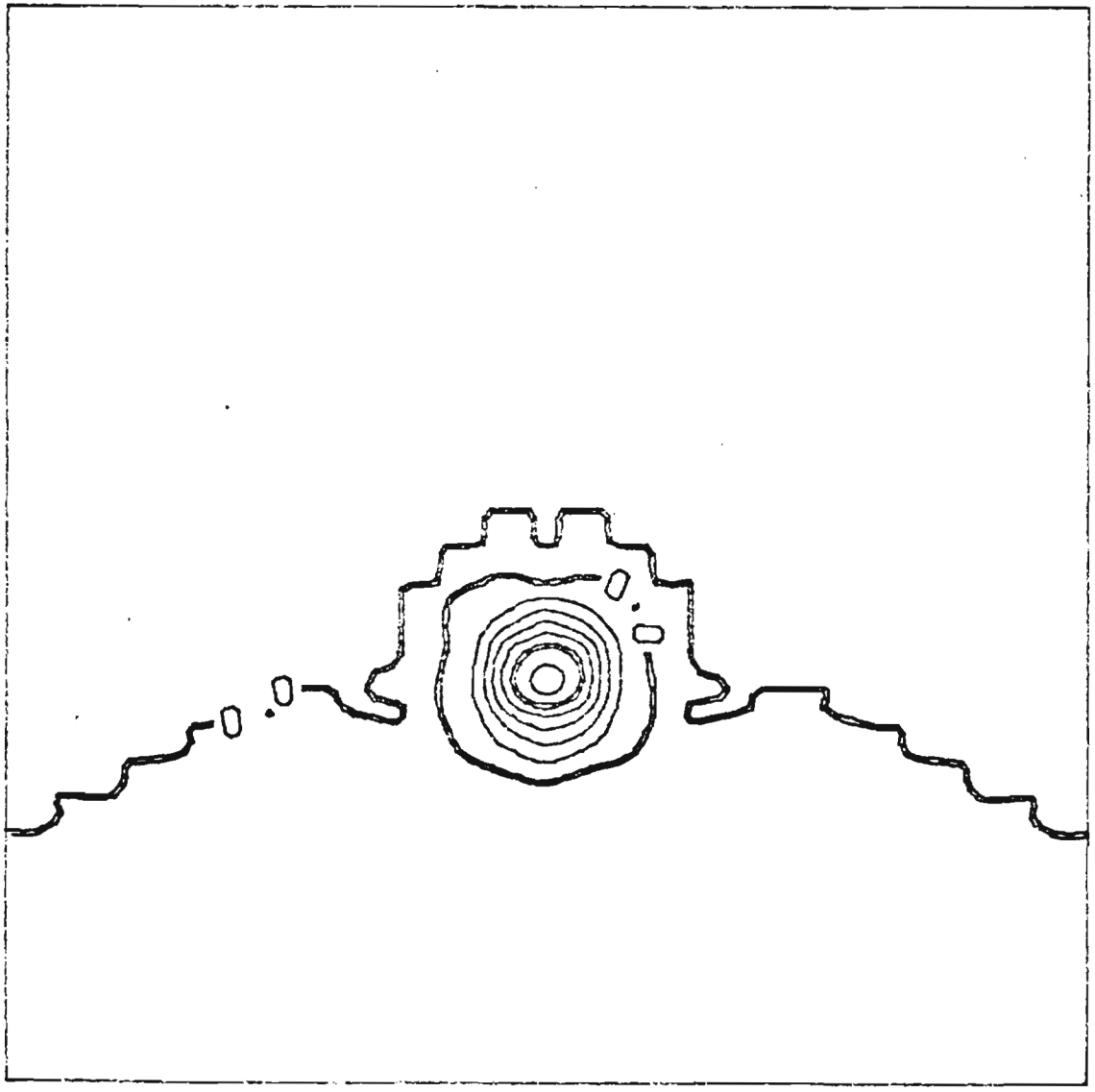


FIGURE 35

Curvature Test
Facet 81, Cone @ 30 cm
RC:Rad = 6:4
Slope Error = 0
Power = 1.0929 kw
Contour Interval = 50

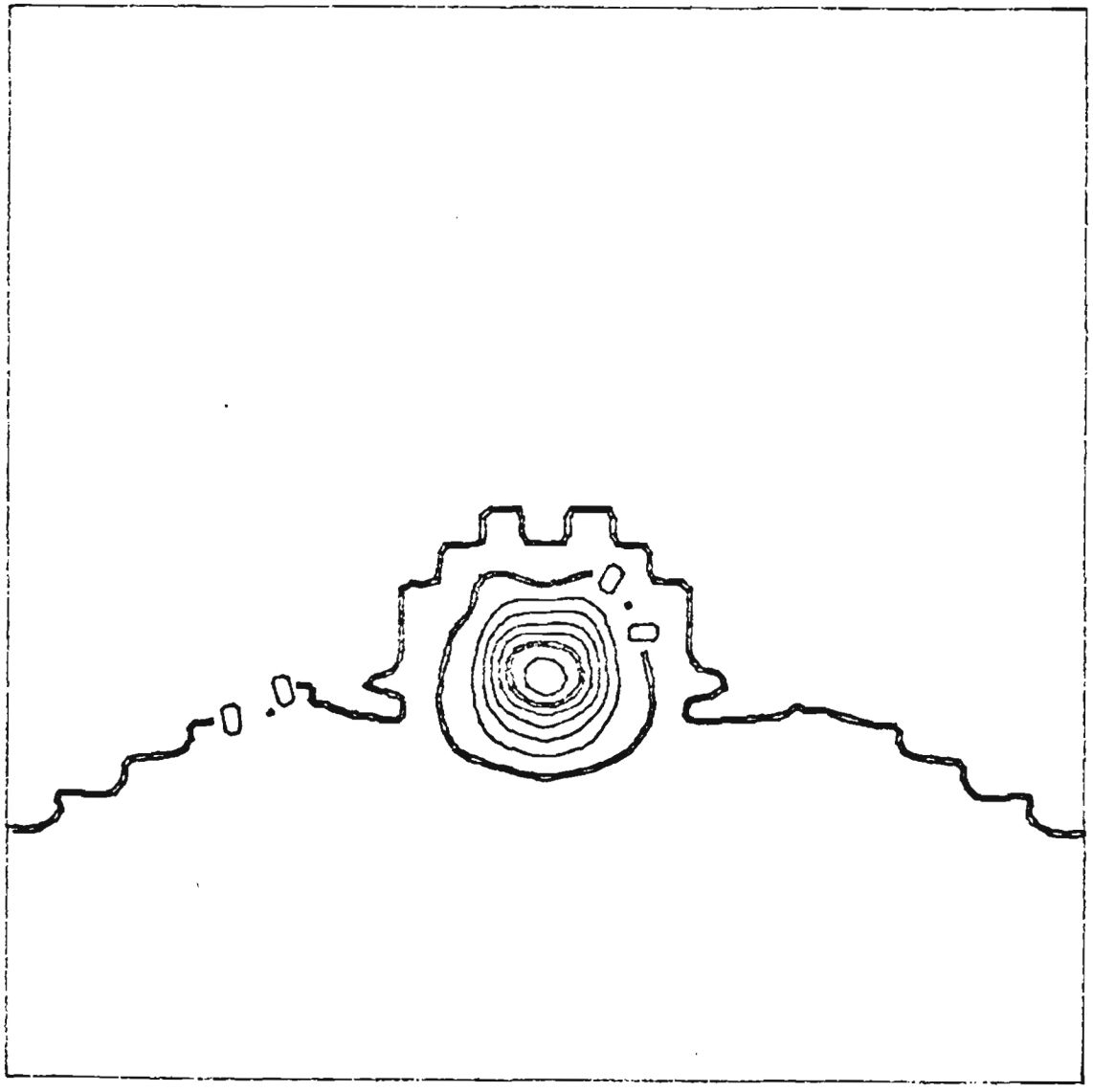


FIGURE 36

Curvature Test
Facet 81, Cone @ 30 cm
RC:Rad = 7:3
Slope Error = 0
Power = 1.0929 kw
Contour Interval = 50

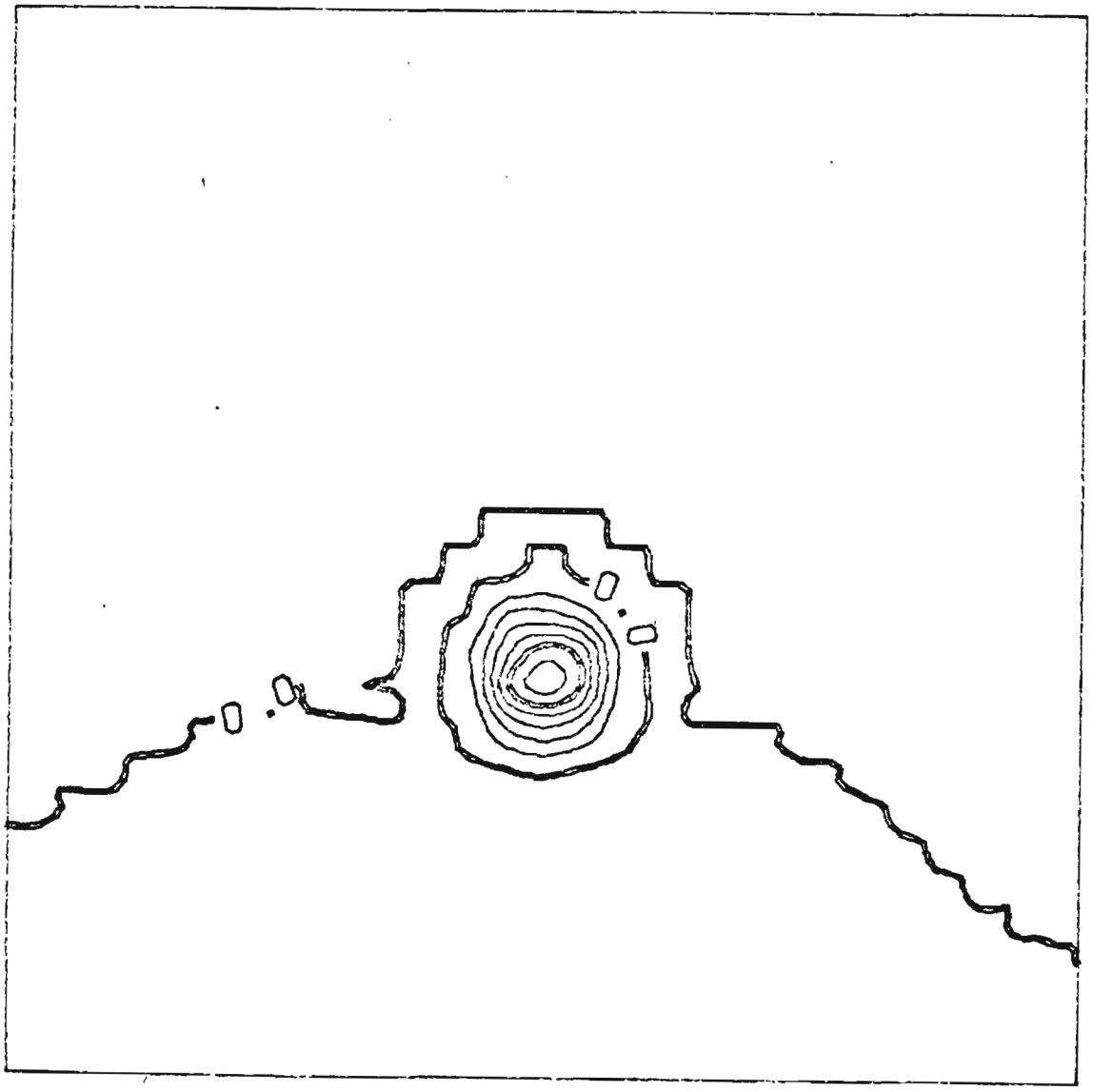


FIGURE 37

Curvature Test
Facet 81, Cone @ 30 cm
RC:Rad = 8:2
Slope Error = 0
Power = 1.0929 kw
Contour Interval = 50

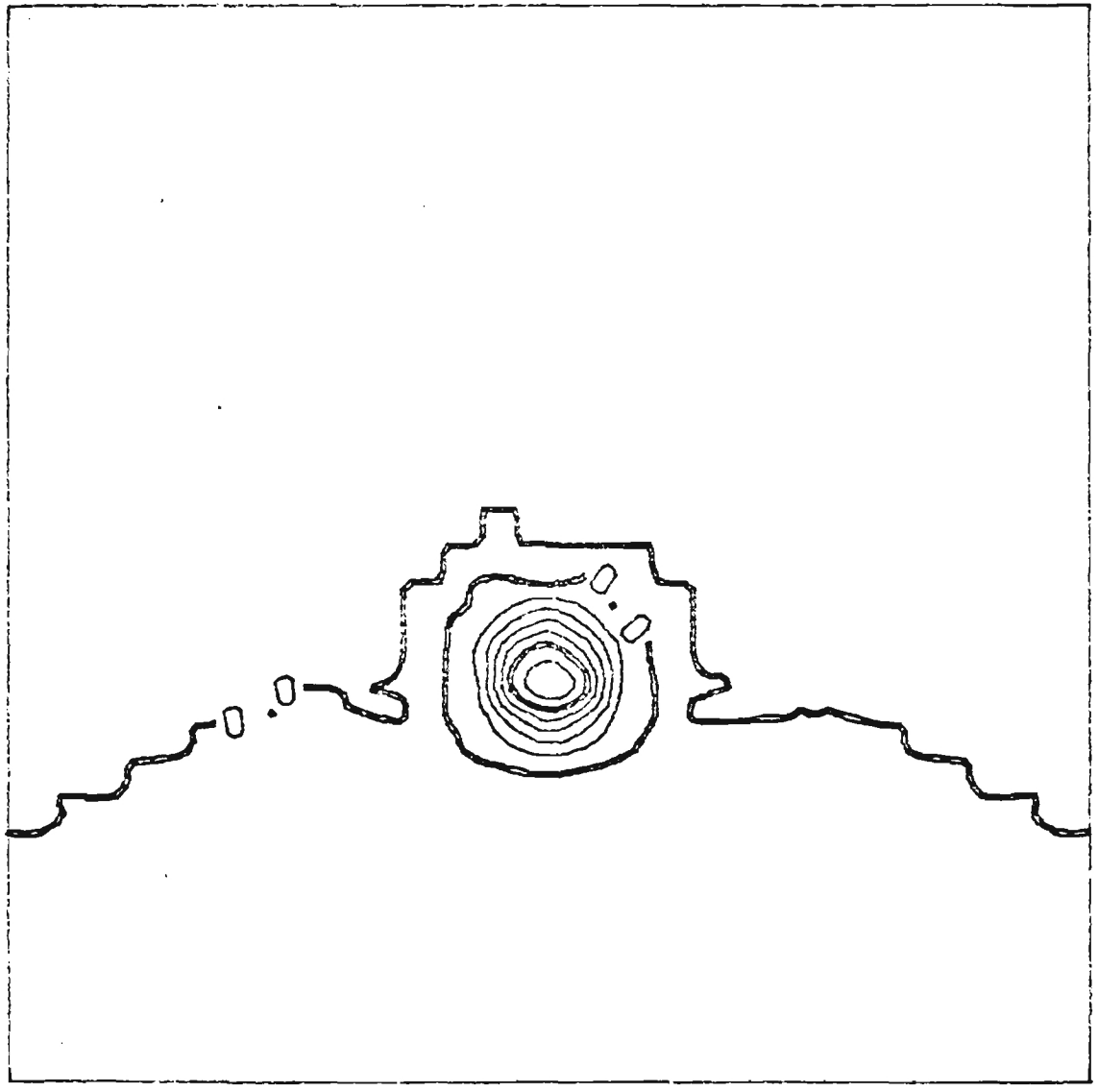


FIGURE 38

Curvature Test
Facet 84, Cone @ 30 cm
RC:Rad = 1:1
Slope Error = 0
Power = 1.0255 kw
Contour Interval = 20

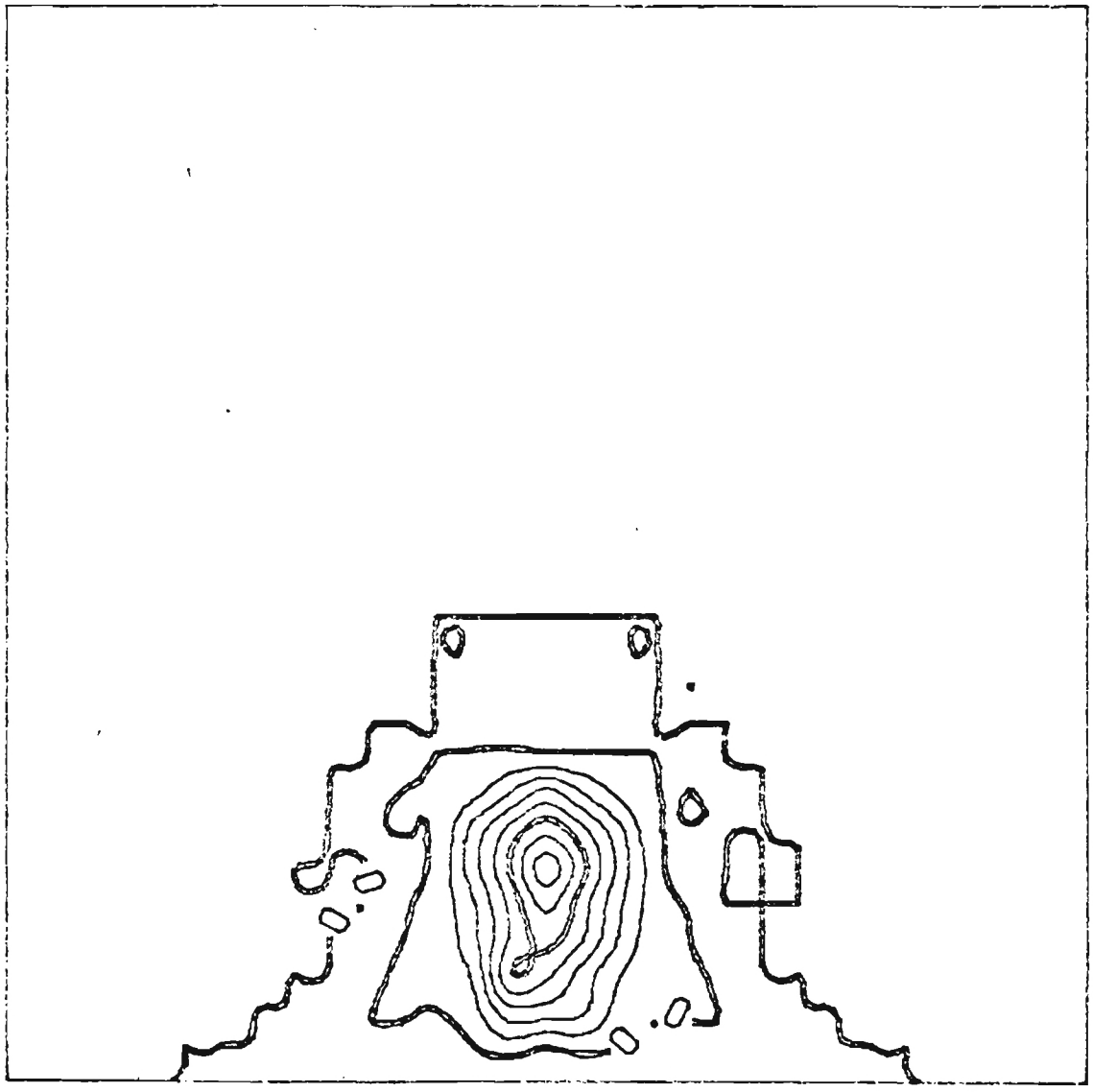


FIGURE 39

Curvature Test
Facet 84, Cone @ 30 cm
RC:Rad = 6:4
Slope Error = 0
Power = 1.0255 kw
Contour Interval = 20

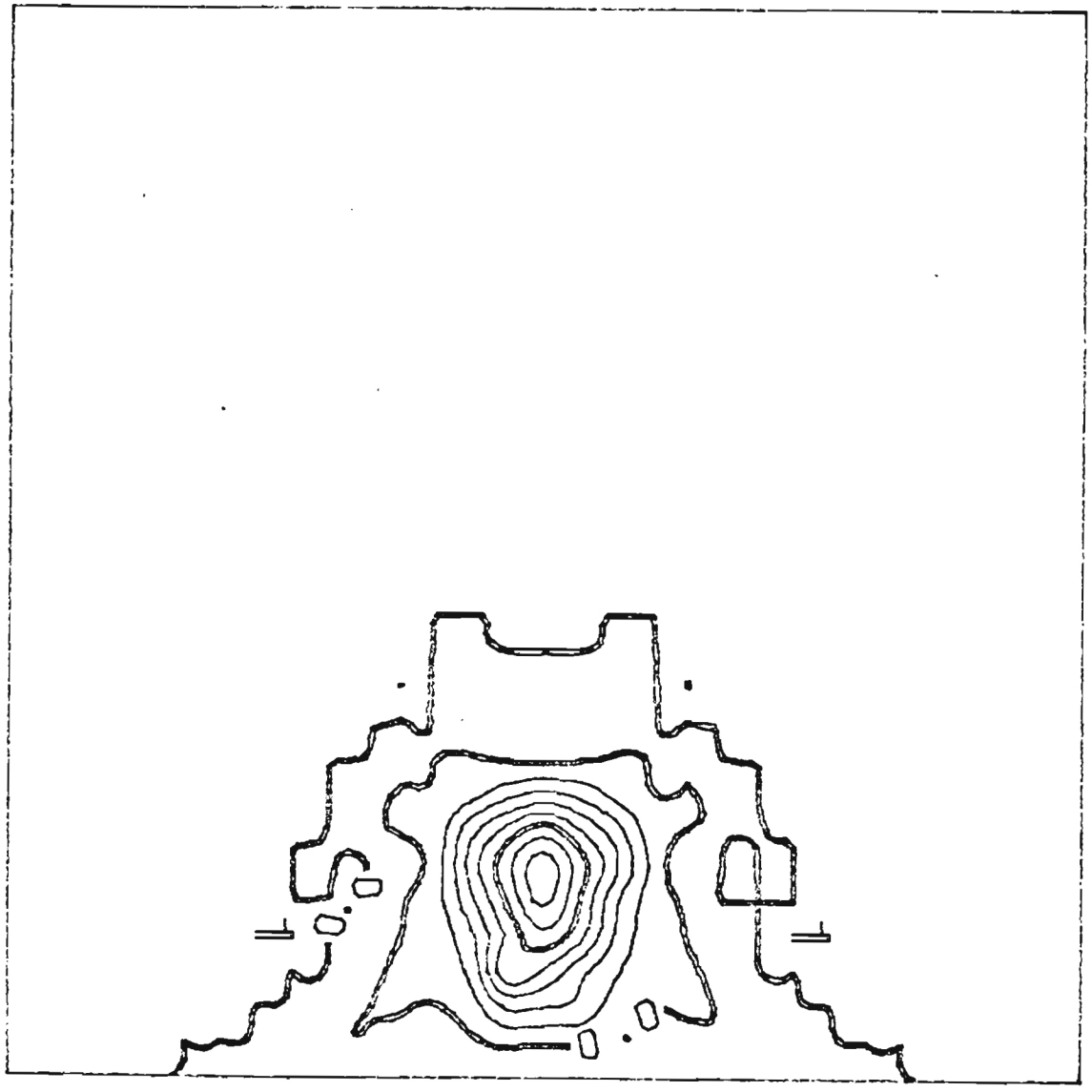


FIGURE 40

Curvature Test
Facet 84, Cone @ 30 cm
RC:Rad = 7:3
Slope Error = 0
Power = 1.0255 kw
Contour Interval = 20

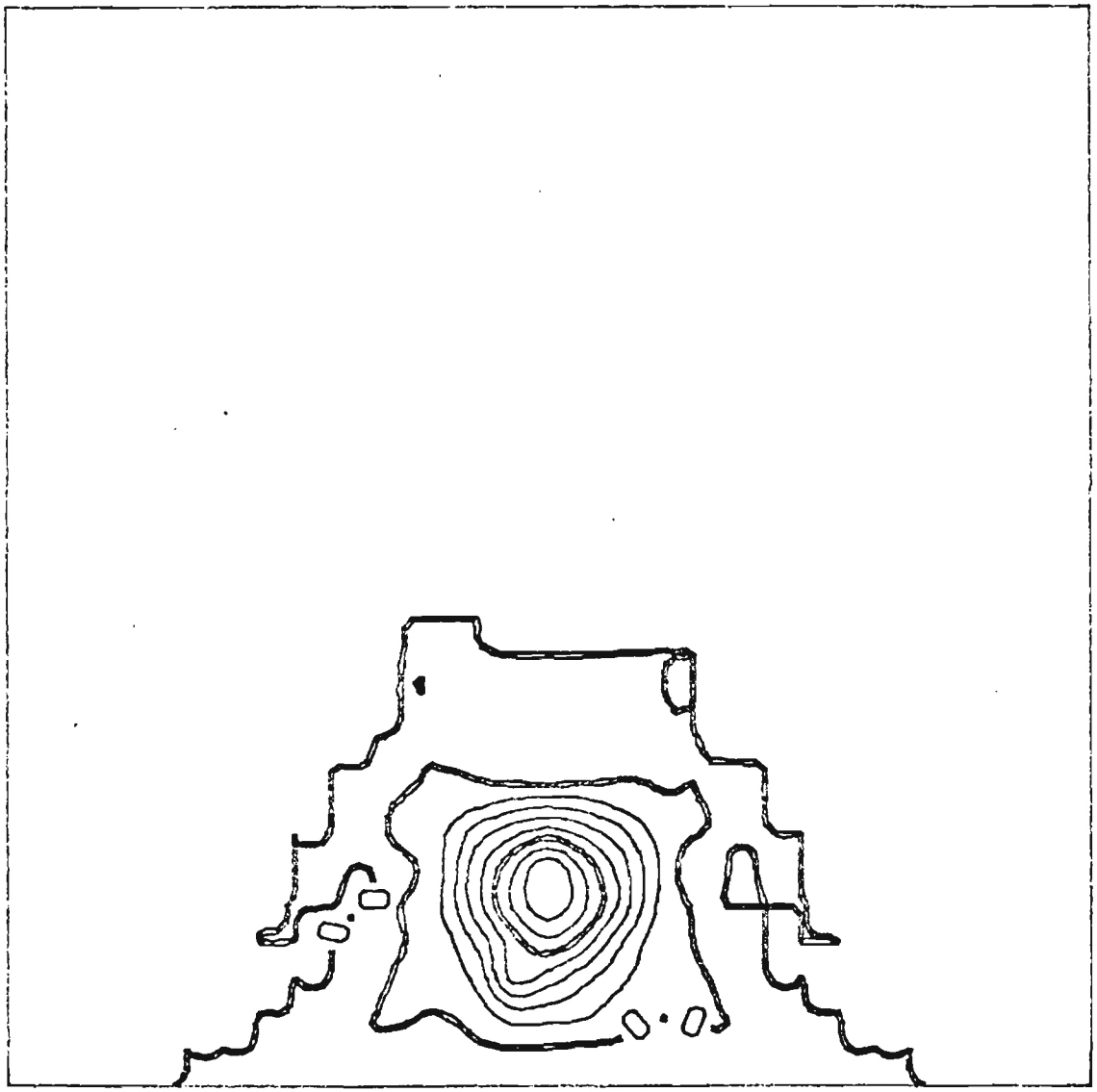


FIGURE 41

Curvature Test
Facet 84, Cone @ 30 cm
RC:Rad = 8:2
Slope Error = 0
Power = 1.0255 kw
Contour Interval = 20

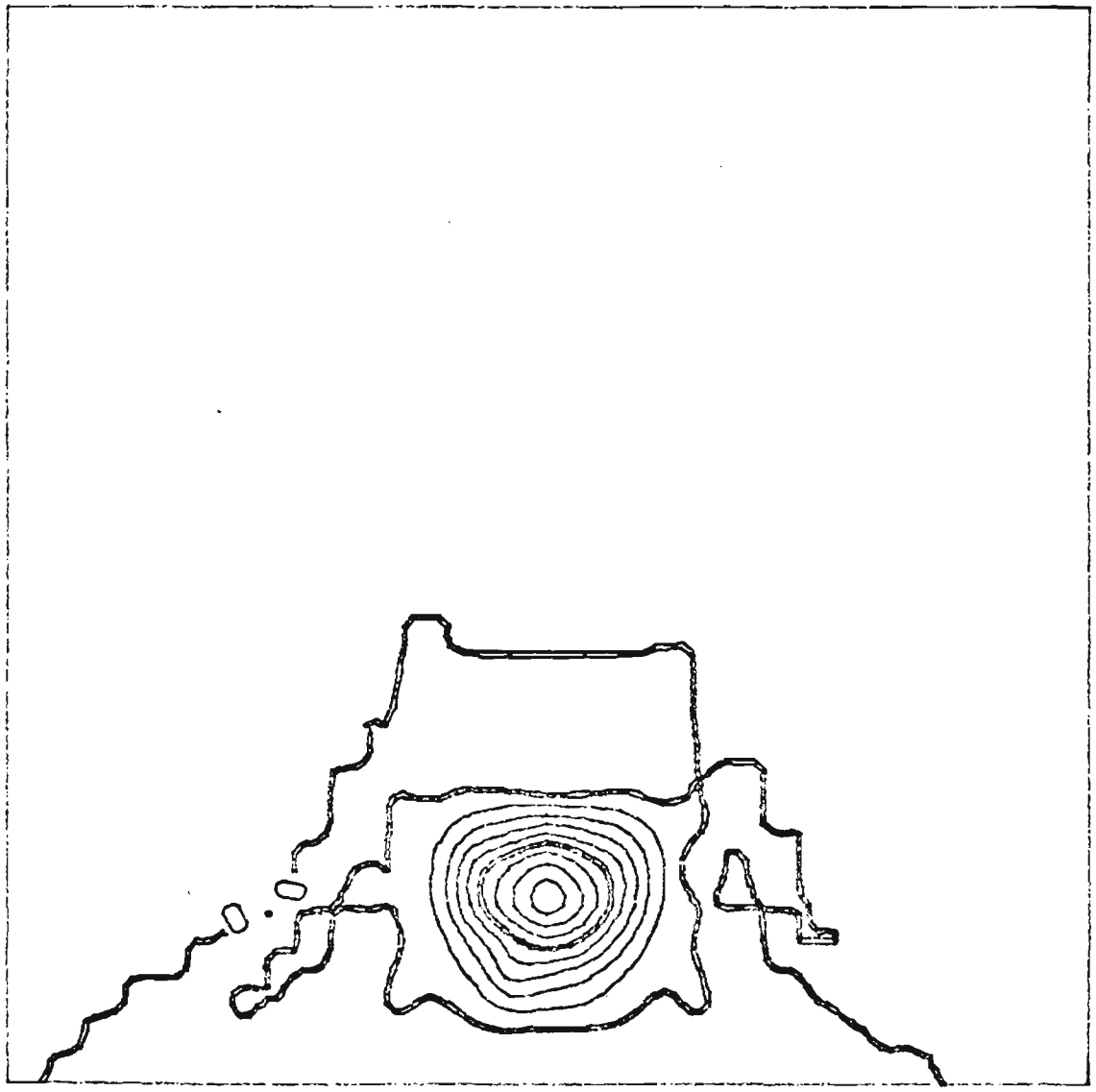


FIGURE 42

Full Dish, Focal Plane
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 20,385.93
Contour Interval = 2500

Flux Value at 90% Power:	2038.05 KW/SQ M
Area Inside 90% Power Contour:	95.03 SQ CM
Power Inside 90% Power Contour:	79.85 KILOWATTS
90% Total Power (Check):	79.85 KILOWATTS

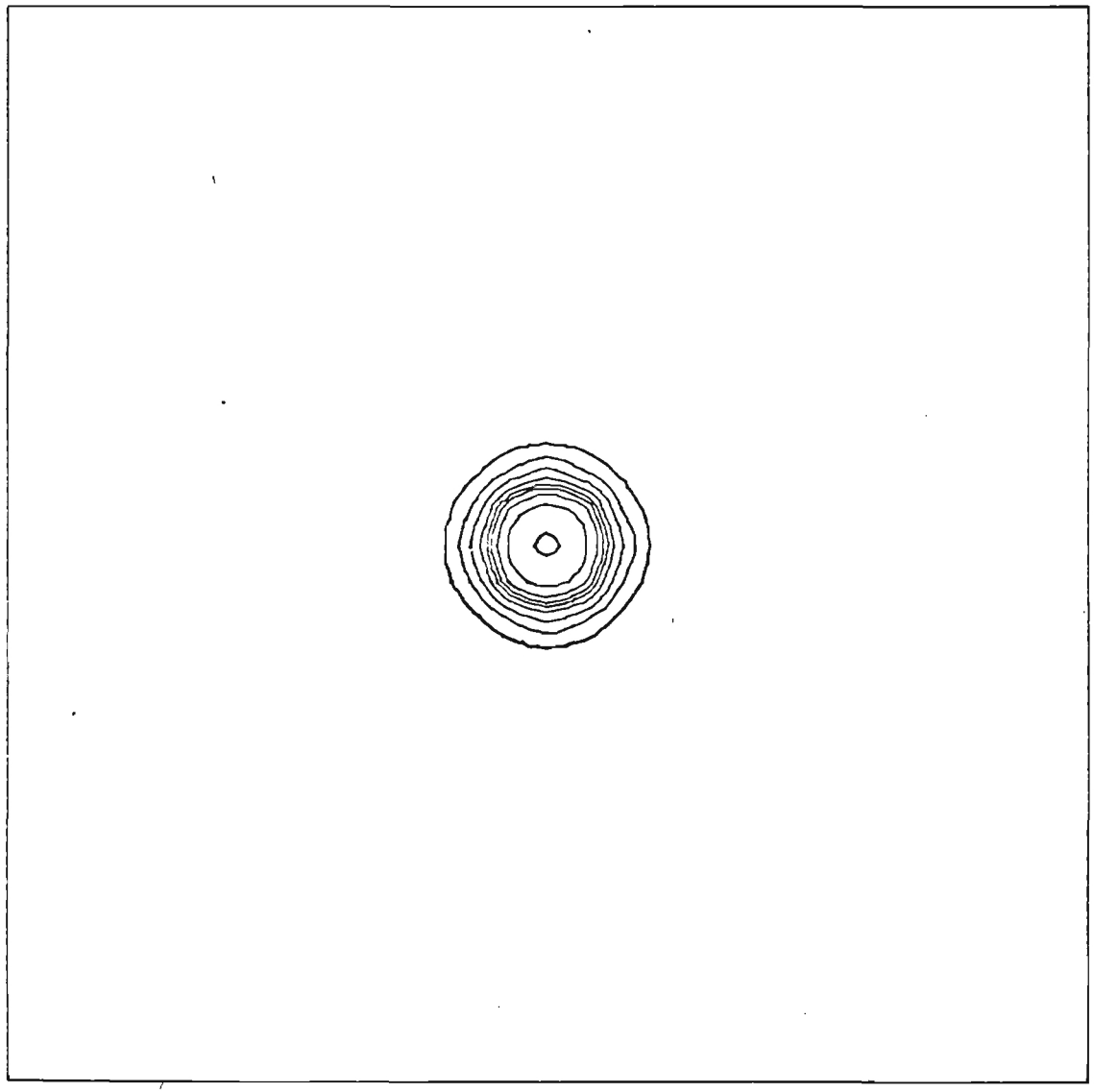


FIGURE 43

Full Dish, Focal Plane
Slope Error = 1.0 mRad
Power = 88.7877 kw
Peak Flux = 17,732.87
Contour Interval = 2500

Flux Value at 90% Power:	1201.33 KW/SQ M
Area Inside 90% Power Contour:	132.73 SQ CM
Power Inside 90% Power Contour:	81.96 KILOWATTS
90% Total Power (Check):	79.91 KILOWATTS

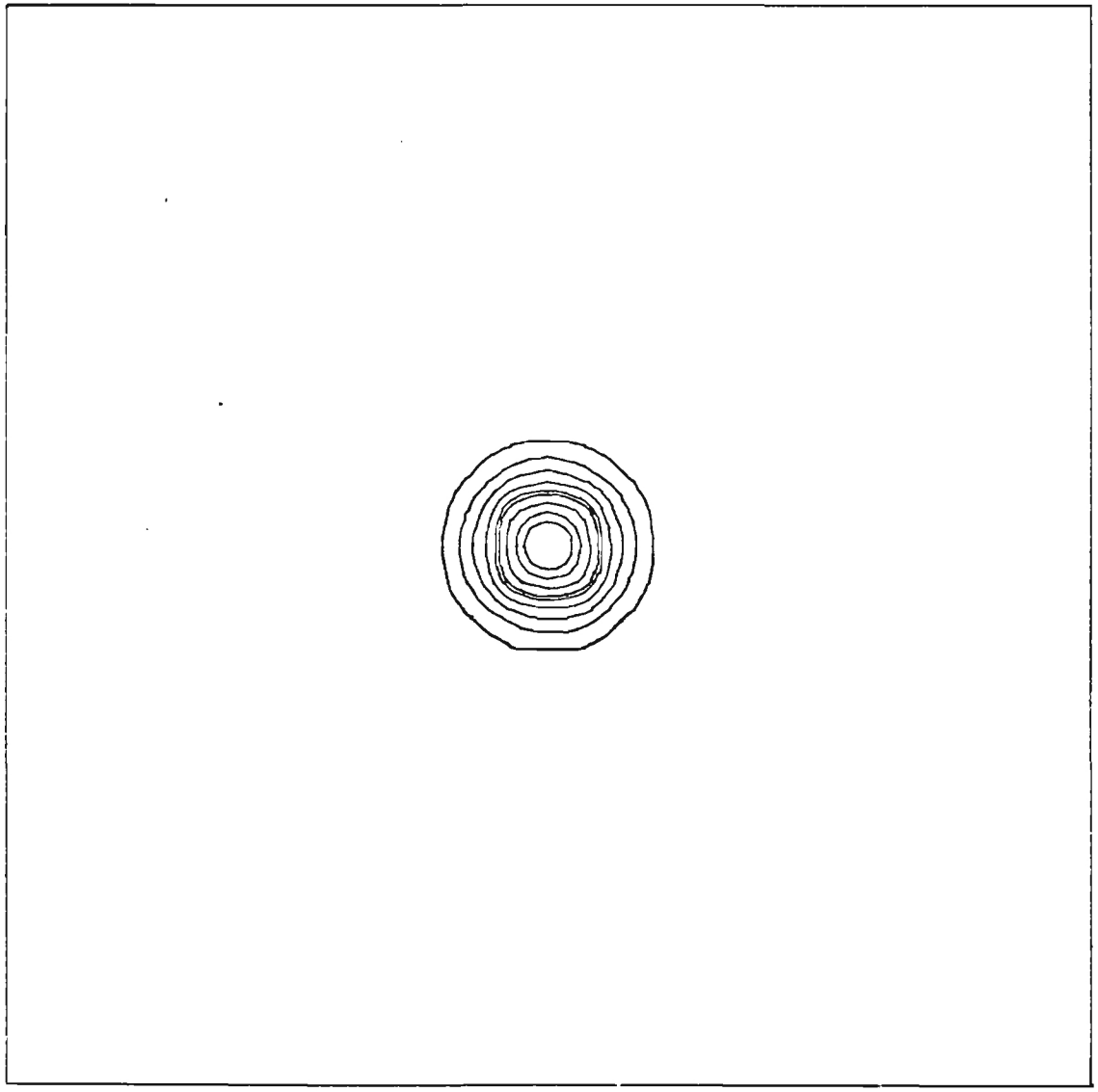


FIGURE 44

Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1400.56
Contour Interval = 100

Flux Value at 90% Power:	284.42 KW/SQ M
Area Inside 90% Power Contour:	853.20 SQ CM
Power Inside 90% Power Contour:	79.85 KILOWATTS
90% Total Power (Check):	79.77 KILOWATTS

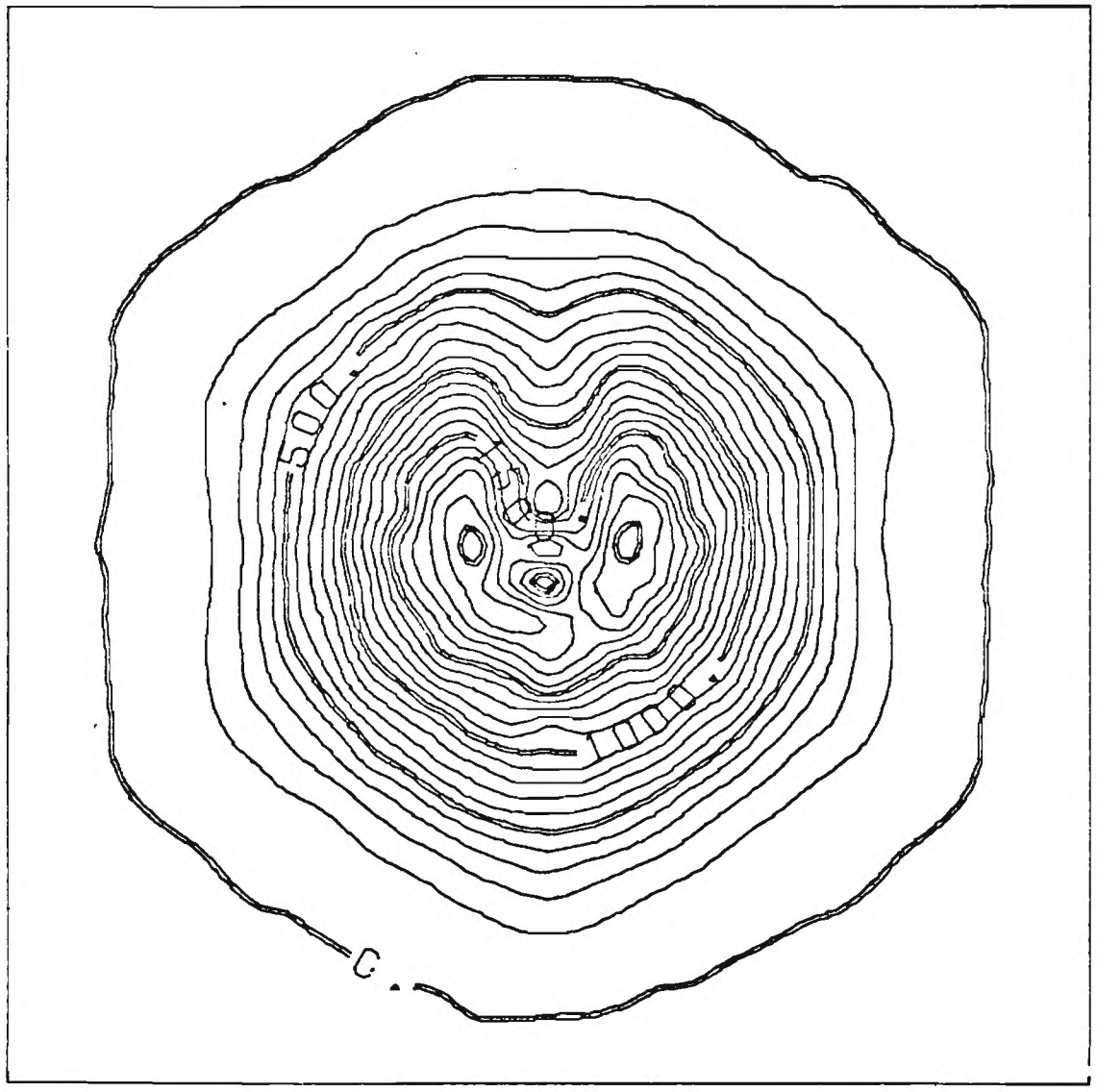


FIGURE 45

Full Plane, Midplane @ 15 cm
Slope Error = 1.0 mRad.
Power = 88.7877 kw
Peak Flux = 1499.59
Contour Interval = 100

Flux Value at 90% Power:	271.02 KW/SQ M
Area Inside 90% Power Contour:	861.93 SQ CM
Power Inside 90% Power Contour:	79.06 KILOWATTS
90% Total Power (Check)	79.44 KILOWATTS

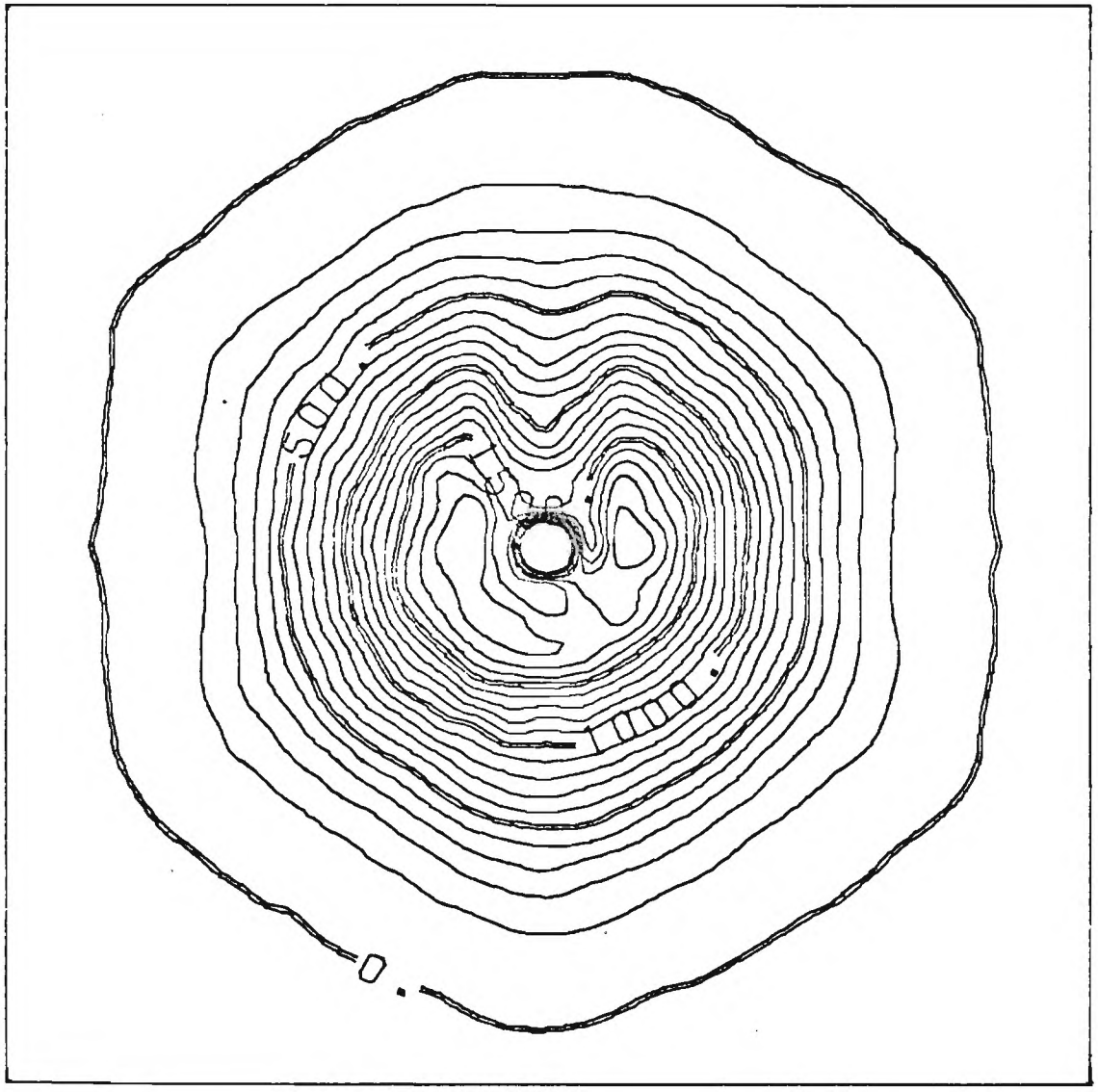


FIGURE 46

Full Dish, Cone @ 30 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 183.91
Contour Interval = 100

Flux Value at 90% Power:	170.01 KW/SQ M
Area Inside 90% Power Contour:	1644.89 SQ CM
Power Inside 90% Power Contour:	82.21 KILOWATTS
90% Total Power (Check):	79.74 KILOWATTS

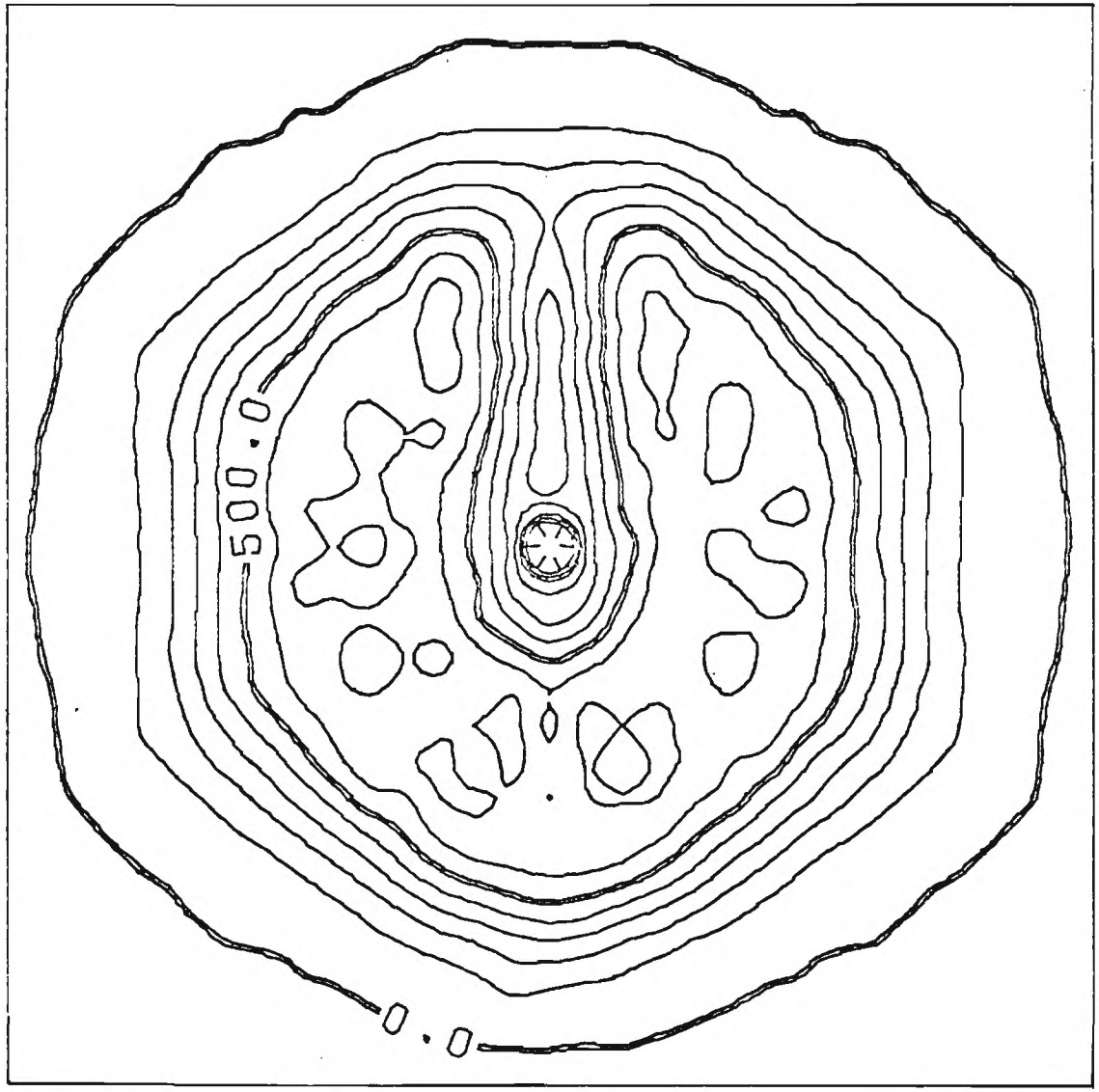


FIGURE 47

Full Dish, Cone @ 30 cm
Slope Error = 1.0 mRad.
Power = 88.7877 kw
Peak Flux = 226.35
Contour Interval = 100

Flux Value at 90% Power:	211.94 KW/SQ M
Area Inside 90% Power Contour:	1545.44 SQ CM
Power Inside 90% Power Contour:	79.43 KILOWATTS
90% Total Power (Check):	79.43 KILOWATTS

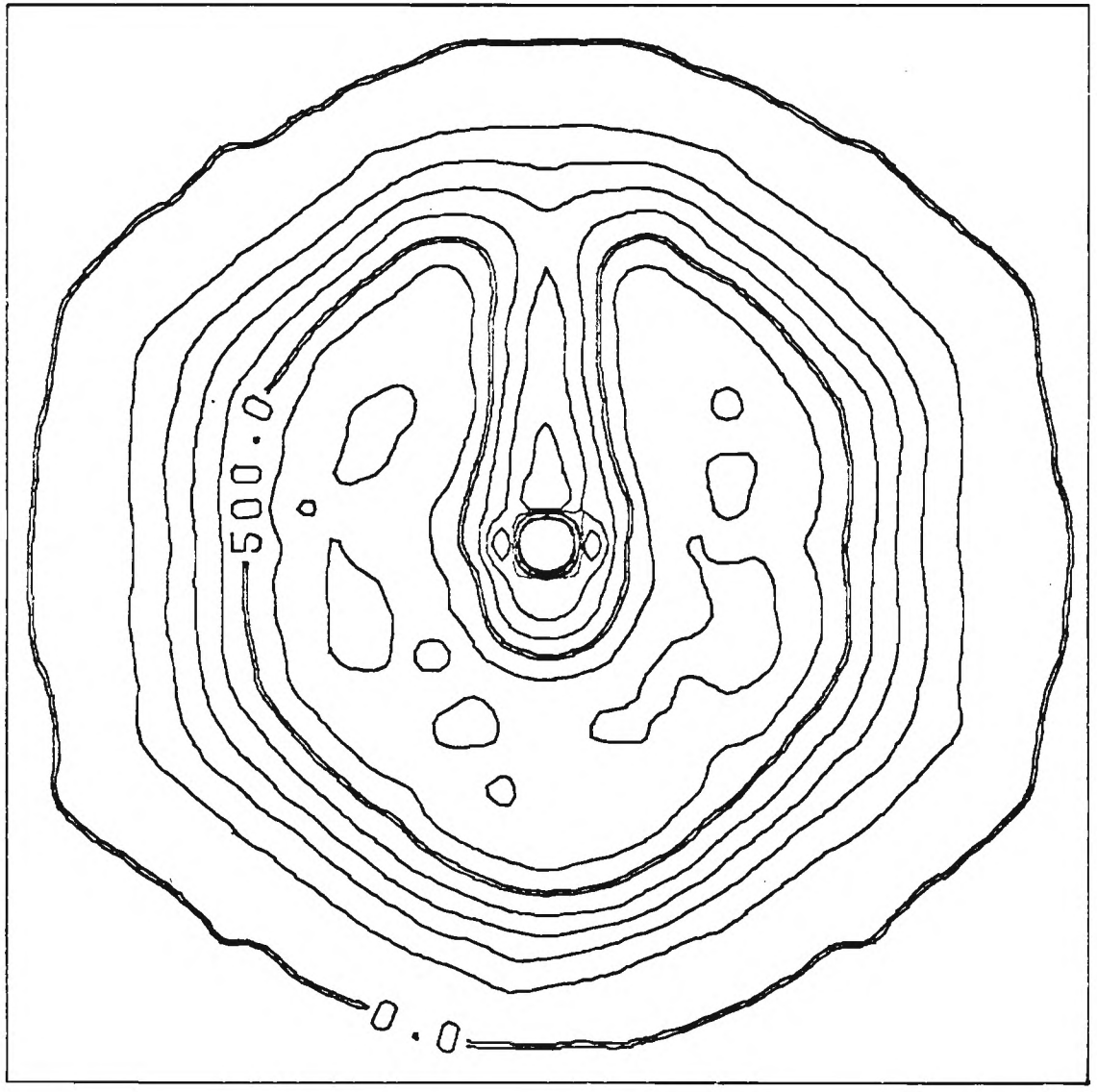


FIGURE 48

Cant Error Test, 0.5 mRad. Cant
Full Dish, Focal Plane
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 19,678.58
Contour Interval = 3000

Flux Value at 90% Power:	1761.91 KW/SQ M
Area Inside 90% Power Contour:	95.03 SQ CM
Power Inside 90% Power Contour:	78.84 KILOWATTS
90% Total Power (Check):	79.88 KILOWATTS

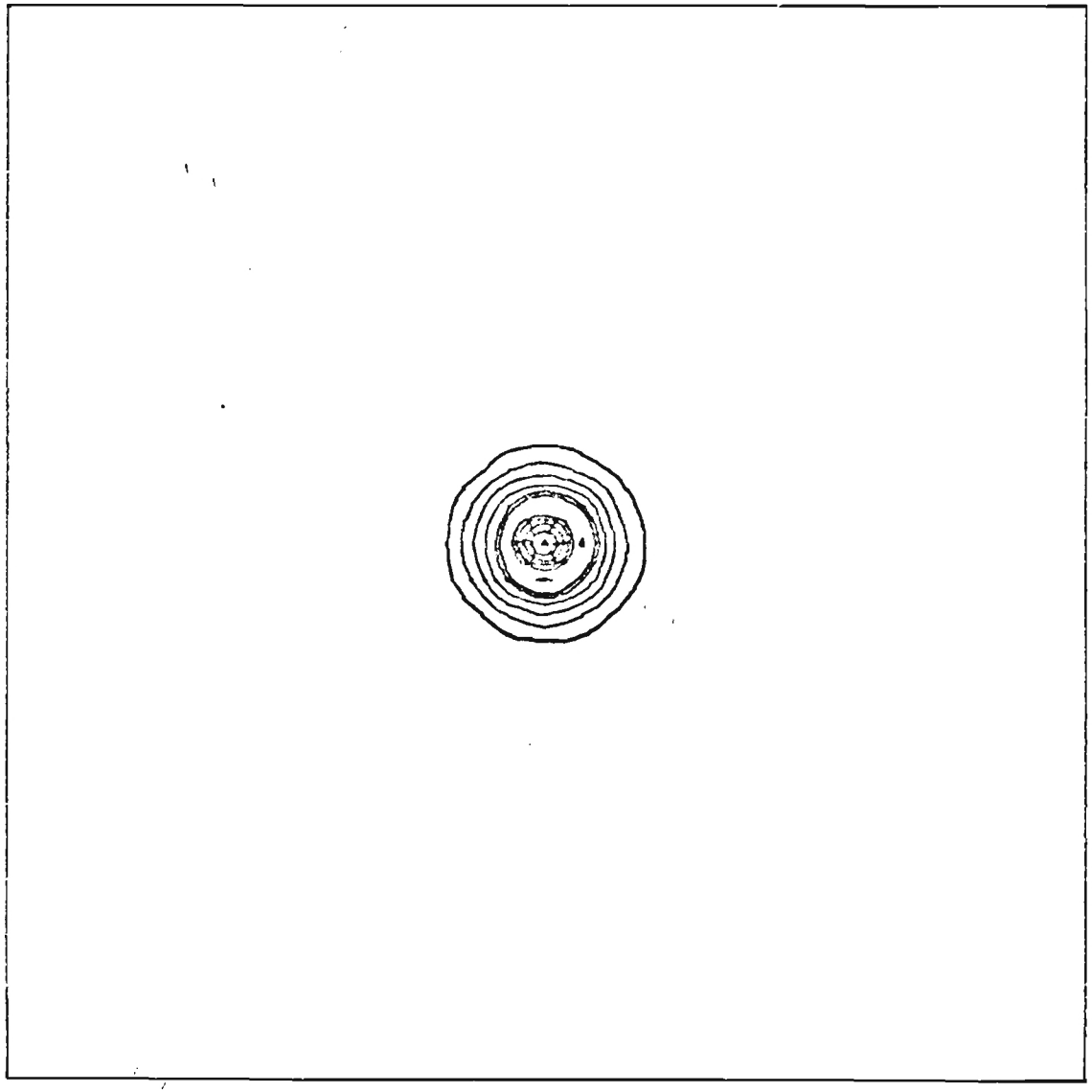


FIGURE 49A

Cant Error Test, 0.5 mRad. Cant
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1216.65
Contour Interval = 100

Flux Value at 90% Power:	272.18 KW/SQ M
Area Inside 90% Power Contour:	865.23 SQ CM
Power Inside 90% Power Contour:	79.59 KILOWATTS
90% Total Power (Check):	79.68 KILOWATTS

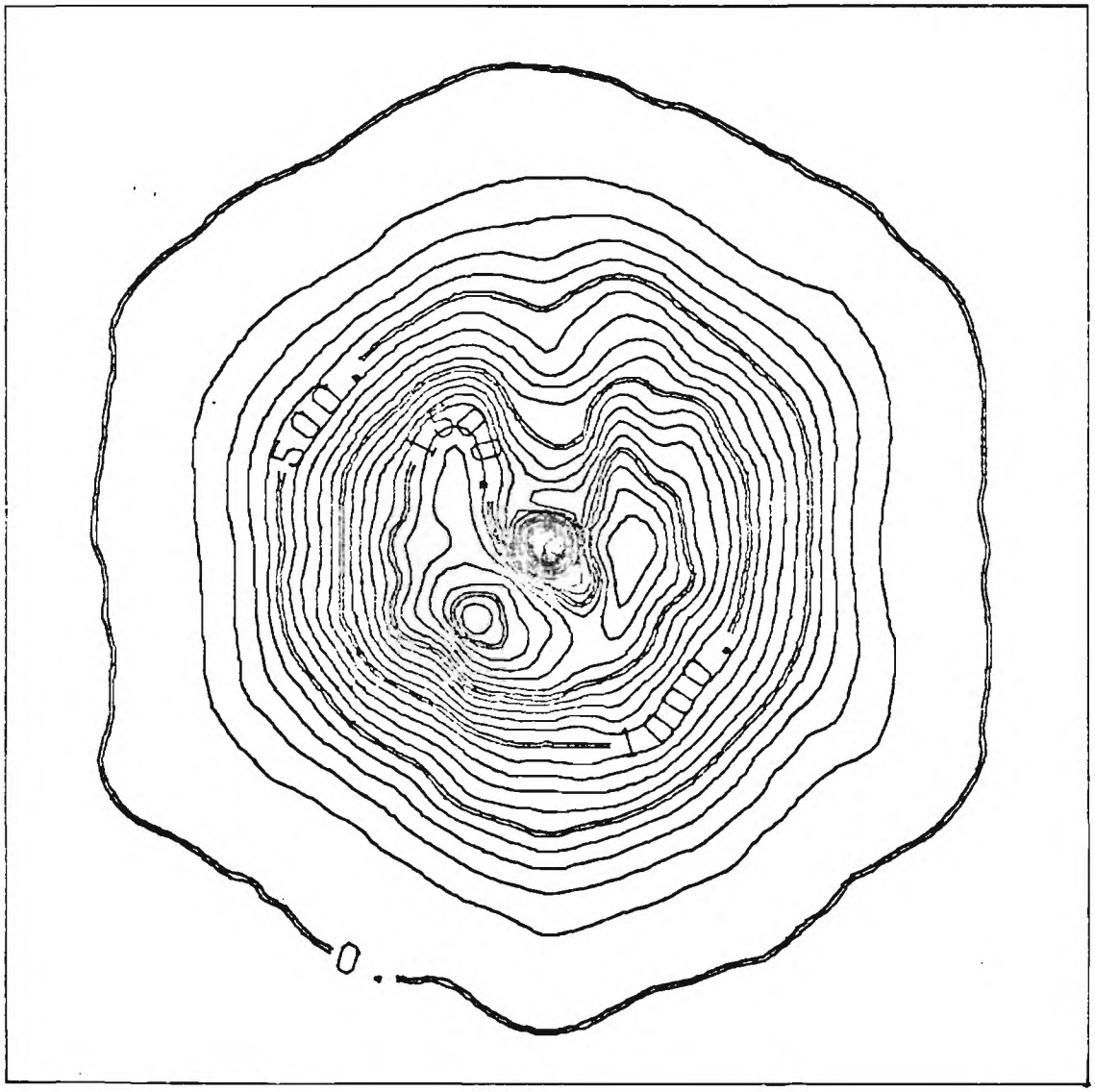


FIGURE 49B

Cant Error Test, 0.5 mRad. Cant
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1216.65
Contour Interval = 500

Flux Value at 90% Power:	272.16 KW/SQ M
Area Inside 90% Power Contour:	865.23 SQ CM
Power Inside 90% Power Contour:	79.59 KILOWATTS
90% Total Power (Check):	79.68 KILOWATTS

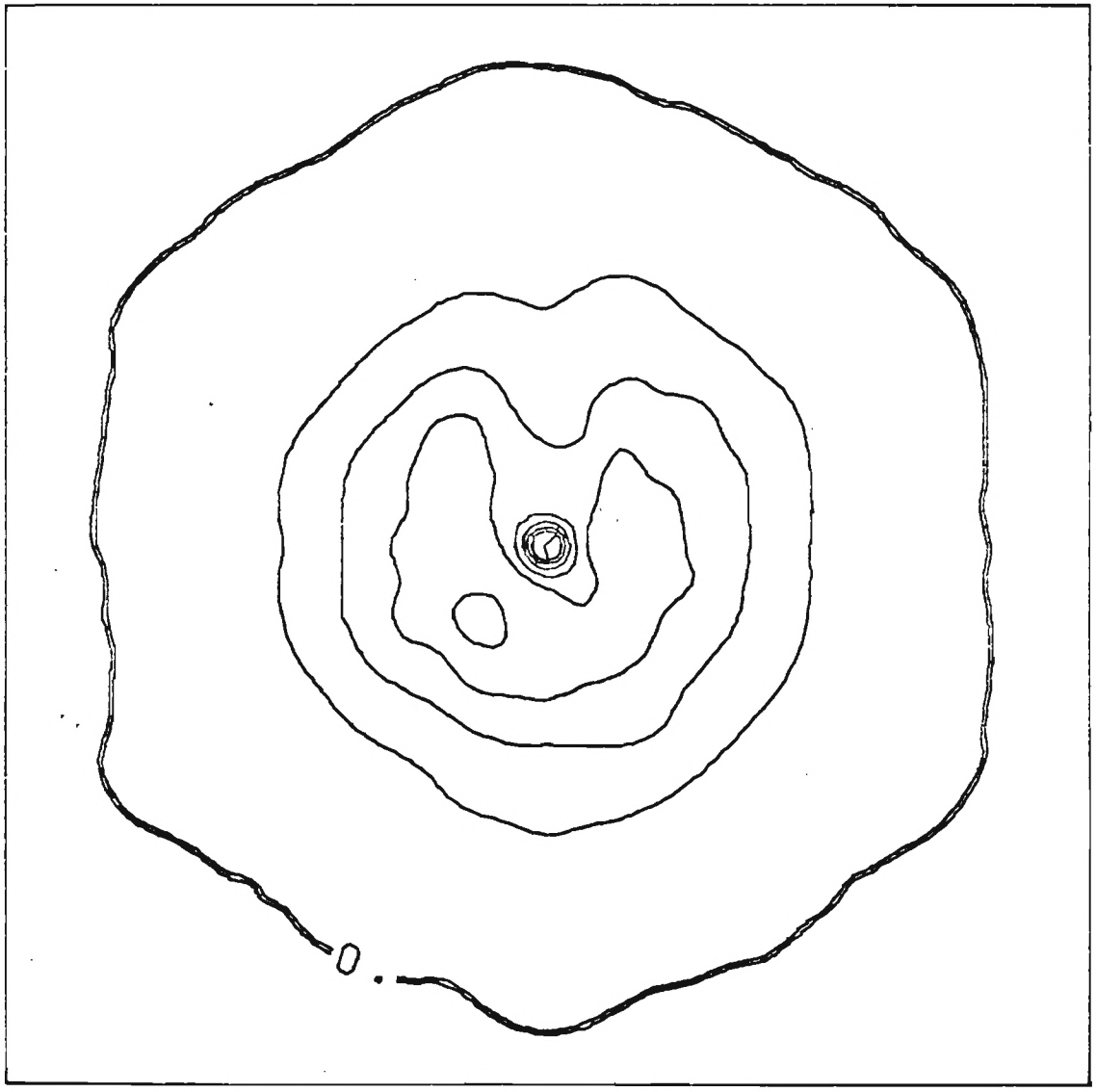


FIGURE 50

Cant Error Test, 0.5 mRad. Cant
Full Dish, Cone @ 30 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 183.91
Contour Interval = 100

Flux Value at 90% Power:	170.73 KW/SQ M
Area Inside 90% Power Contour:	1650.72 SQ CM
Power Inside 90% Power Contour:	81.85 KILOWATTS
90% Total Power (Check):	79.66 KILOWATTS

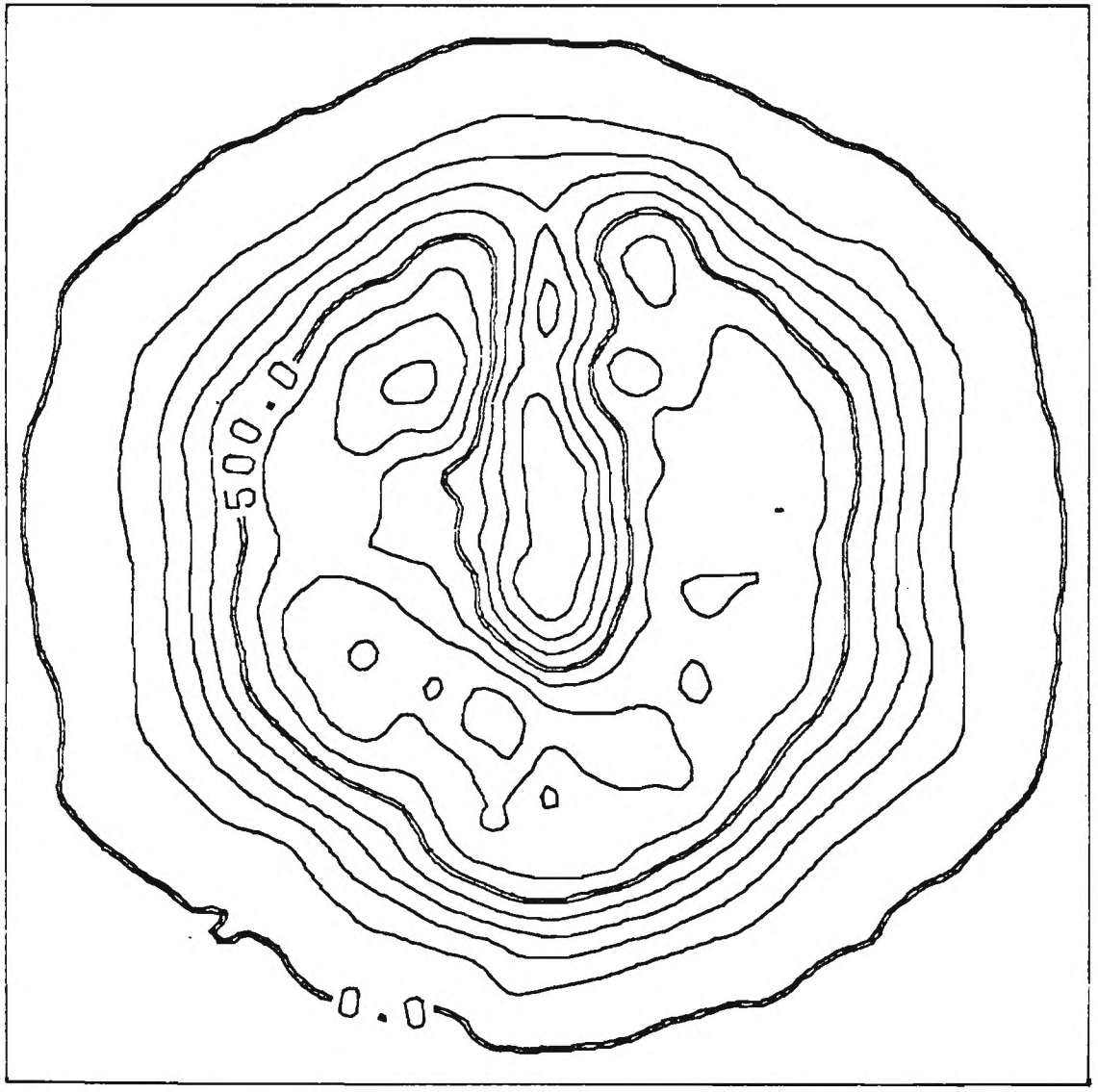


FIGURE 51

Cant Error Test, 1.0 mRad. Cant
Full Dish, Focal Plane
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 18,263.87
Contour Interval = 3000

Flux Value at 90% Power:	1385.70 KW/SQ M
Area Inside 90% Power Contour:	122.26 SQ CM
Power Inside 90% Power Contour:	81.51 KILOWATTS
90% Total Power (Check):	79.91 KILOWATTS

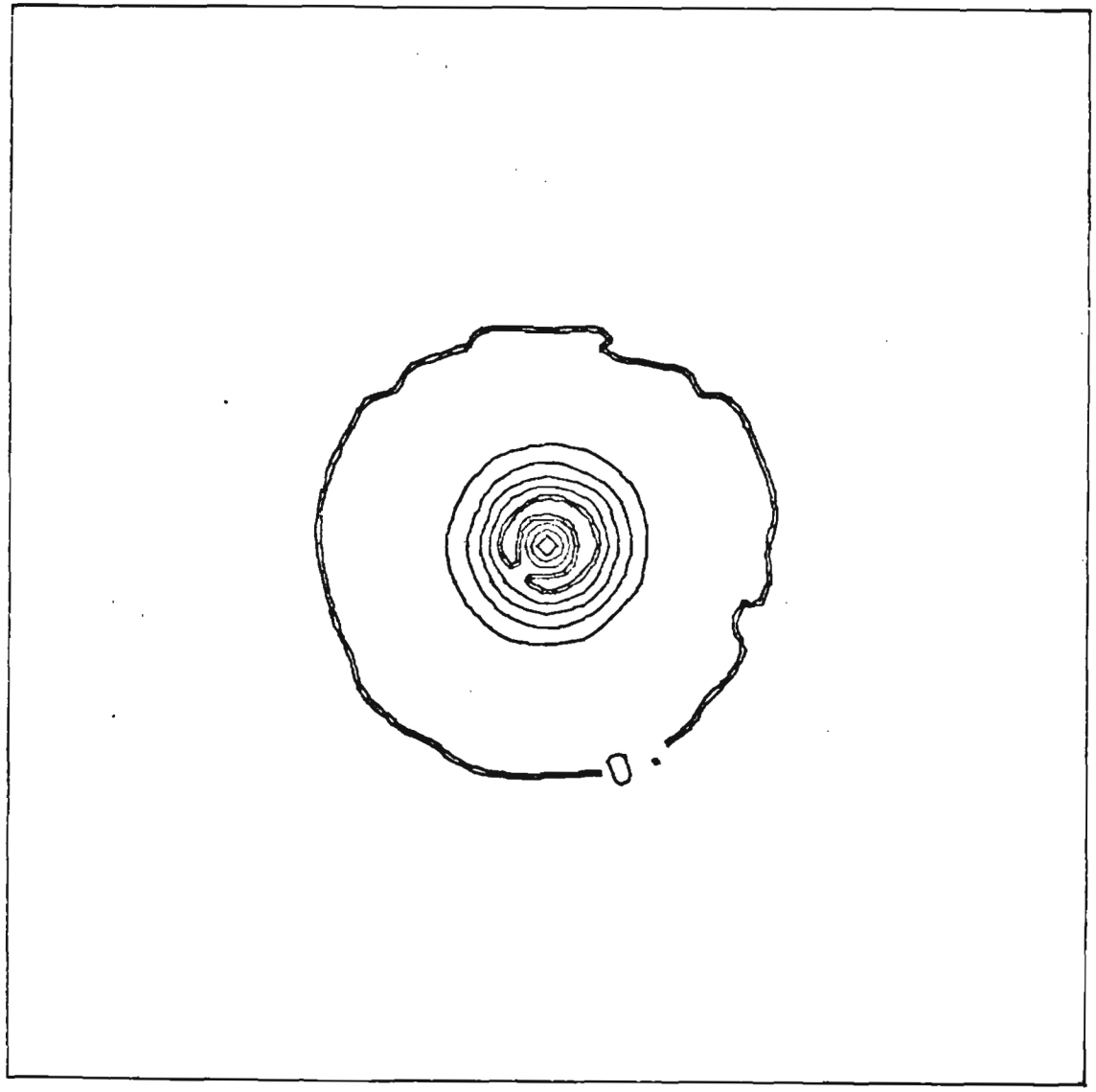


FIGURE 52A

Cant Error Test, 1.0 mRad. Cant
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1839.12
Contour Interval = 100

Flux Value at 90% Power:	277.75 KW/SQ M
Area Inside 90% Power Contour:	825.28 SQ CM
Power Inside 90% Power Contour:	79.48 KILOWATTS
90% Total Power (Check):	79.49 KILOWATTS

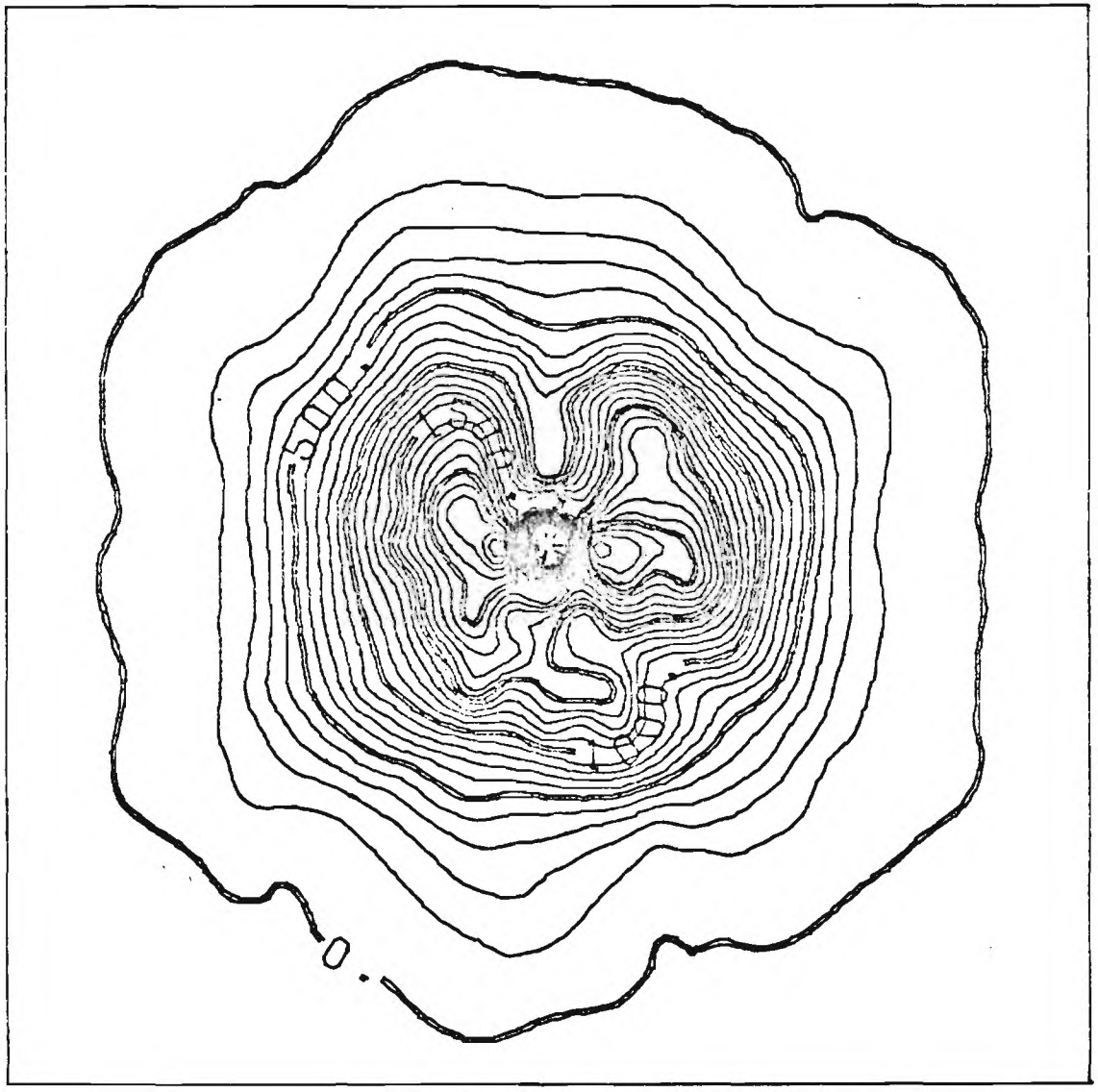


FIGURE 52B

Cant Error Test, 1.0 mRad. Cant
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1839.12
Contour Interval = 500

Flux Value at 90% Power:	277.75 KW/SQ M
Area Inside 90% Power Contour:	825.28 SQ CM
Power Inside 90% Power Contour:	79.48 KILOWATTS
90% Total Power (Check):	79.49 KILOWATTS

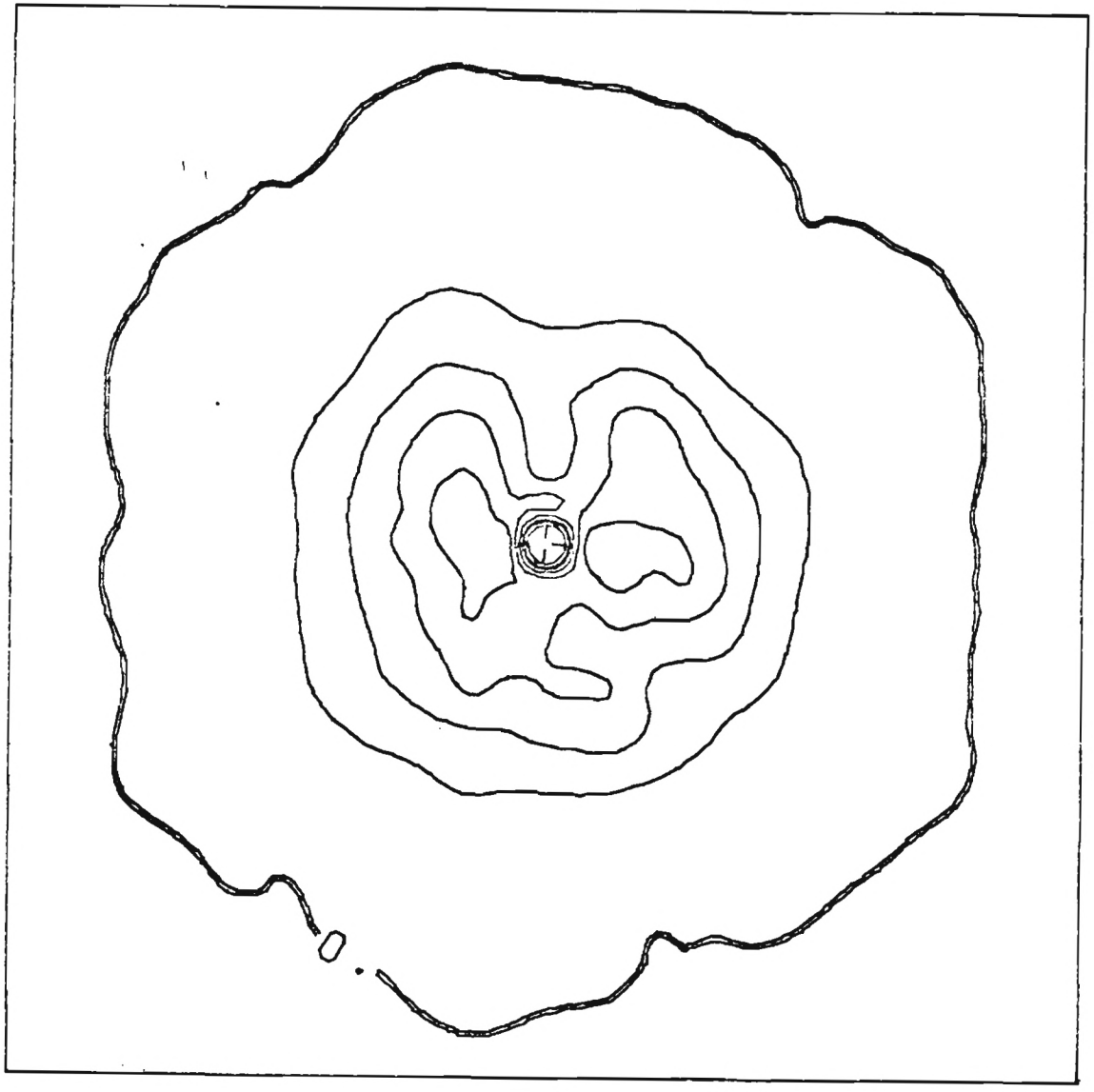


FIGURE 53

Cant Error Test, 1.0 mRad. Cant
Full Dish, Cone @ 30 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 311.24
Contour Interval = 100

Flux Value at 90% Power:	216.74 KW/SQ M
Area Inside 90% Power Contour:	1480.57 SQ CM
Power Inside 90% Power Contour:	79.44 KILOWATTS
90% Total Power (Check):	79.49 KILOWATTS

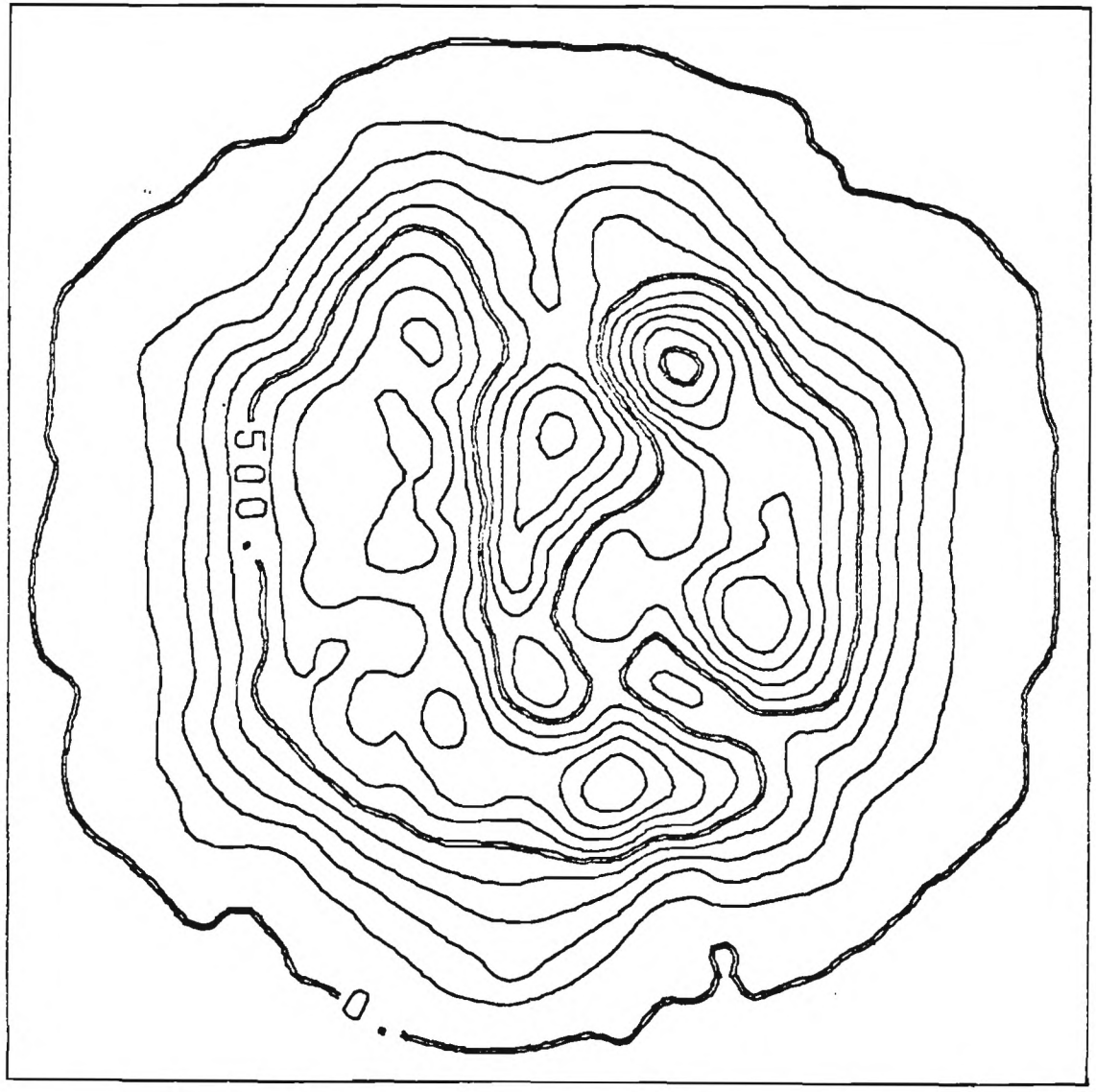


FIGURE 54

Pointing Error Test
2.0 mRad. Pointing Error About Z-Axis
Full Dish, Focal Plane
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 13,185.07
Contour Interval = 2000

Flux Value at 90% Power:	1154.39 KW/SQ M
Area Inside 90% Power Contour:	151.06 SQ CM
Power Inside 90% Power Contour:	79.92 KILOWATTS
90% Total Power (Check):	79.91 KILOWATTS

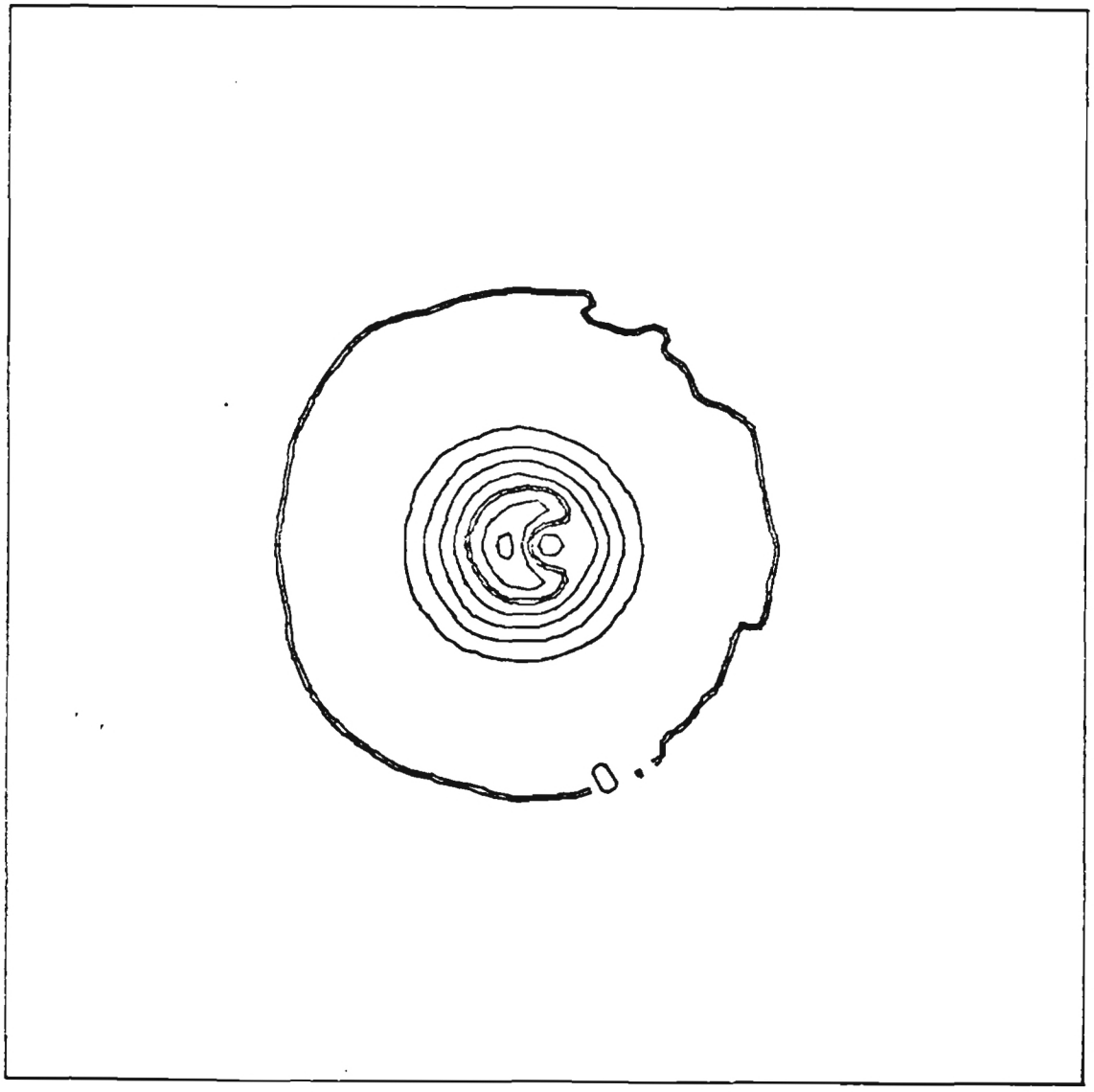


FIGURE 55

Pointing Error Test
2.0 mRad. Pointing Error About Z-Axis
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 2475.74
Contour Interval = 500

Flux Value at 90% Power:	291.89 KW/SQ M
Area Inside 90% Power Contour:	862.80 SQ CM
Power Inside 90% Power Contour:	78.43 KILOWATTS
90% Total Power (Check):	78.47 KILOWATTS

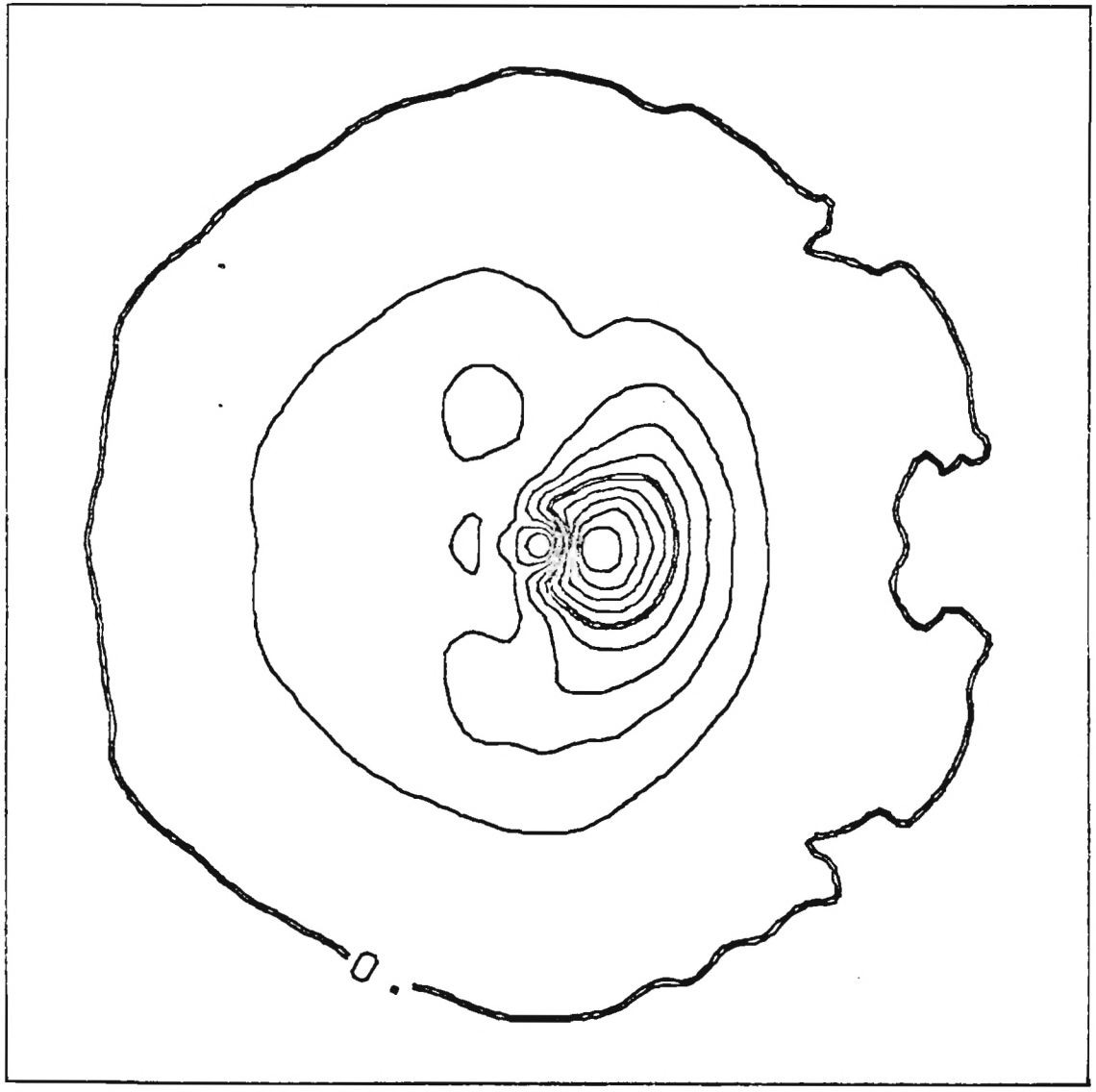


FIGURE 56

Pointing Error Test
2.0 mRad. Pointing Error About Z-Axis
Full Dish, Cone @ 30 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 509.29
Contour Interval = 100

Flux Value at 90% Power:	216.14 KW/SQ M
Area Inside 90% Power Contour:	1516.72 SQ CM
Power Inside 90% Power Contour:	78.68 KILOWATTS
90% Total Power (Check):	78.45 KILOWATTS

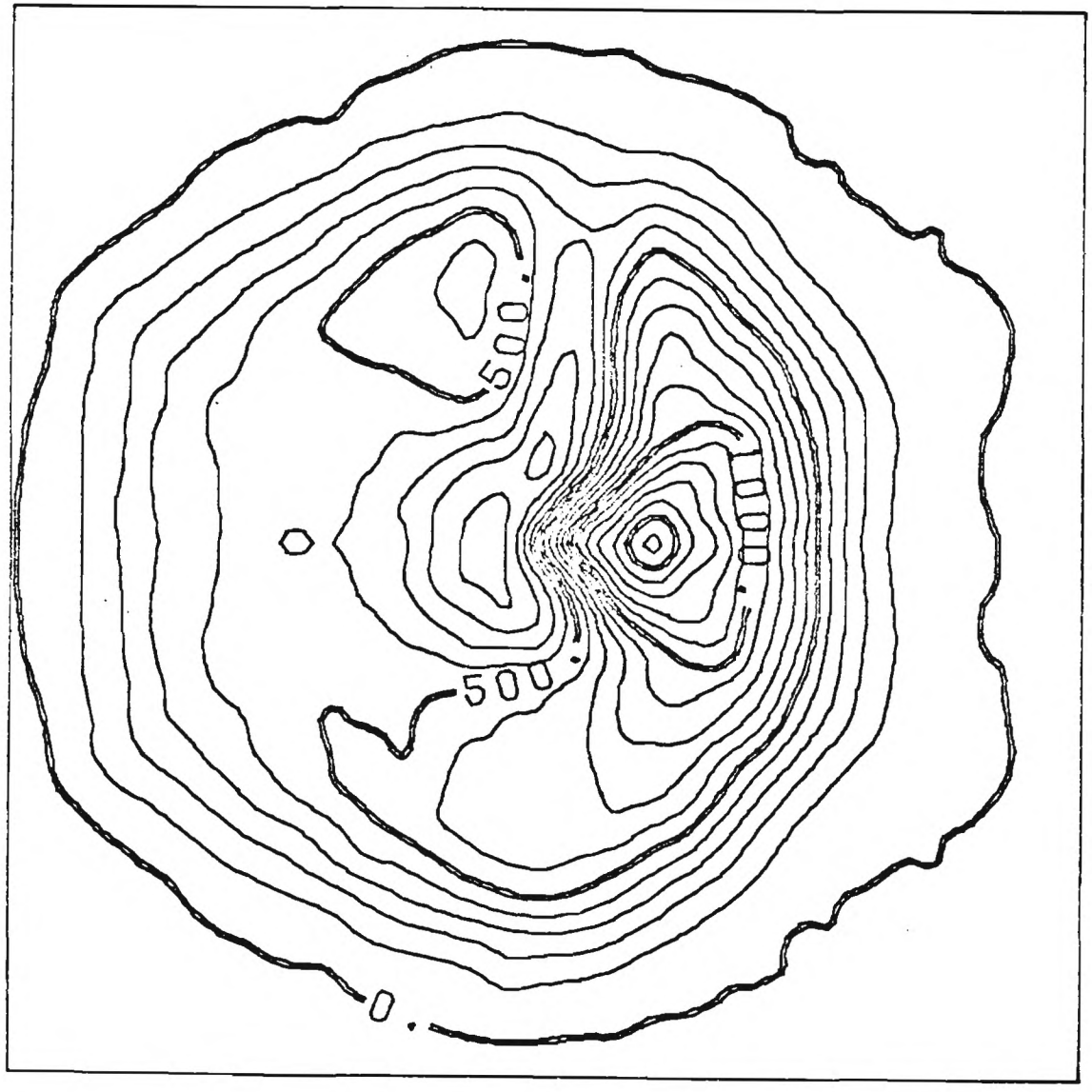


FIGURE 57

Radius Error Test, 10cm Avg. Error
Full Dish, Focal Plane
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 20,371.79
Contour Interval = 2500

Flux Value at 90% Power:	2037.15 KW/SQ M
Area Inside 90% Power Contour:	95.03 SQ CM
Power Inside 90% Power Contour:	79.84 KILOWATTS
90% Total Power (Check):	79.91 KILOWATTS

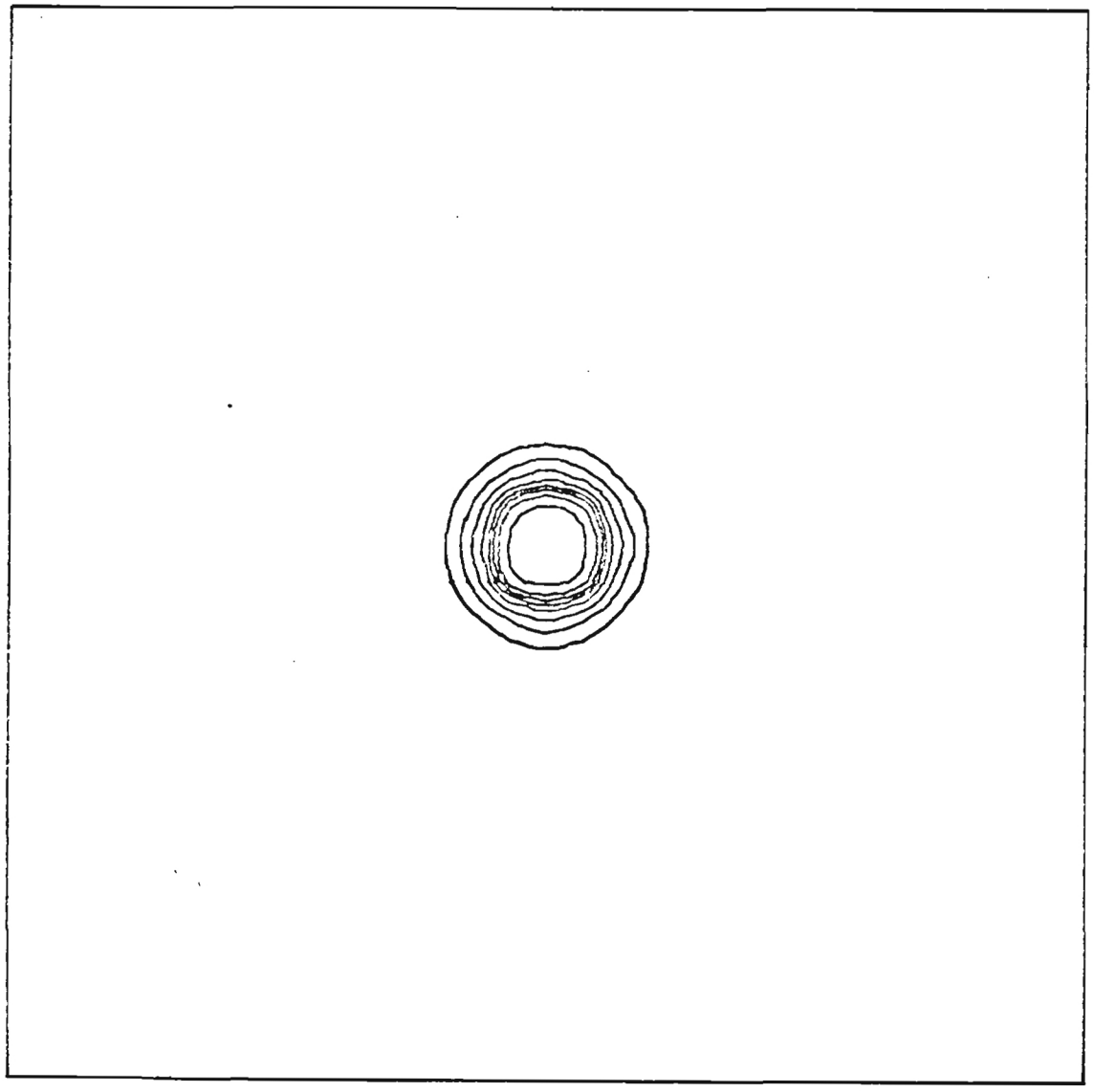


FIGURE 58

Radius Error Test, 10 cm Avg. Error
Full Dish, Midplane @ 15 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 1428.85
Contour Interval = 100

Flux Value at 90% Power:	287.98 KW/SQ M
Area Inside 90% Power Contour:	850.41 SQ CM
Power Inside 90% Power Contour:	79.76 KILOWATTS
90% Total Power (Check):	79.76 KILOWATTS

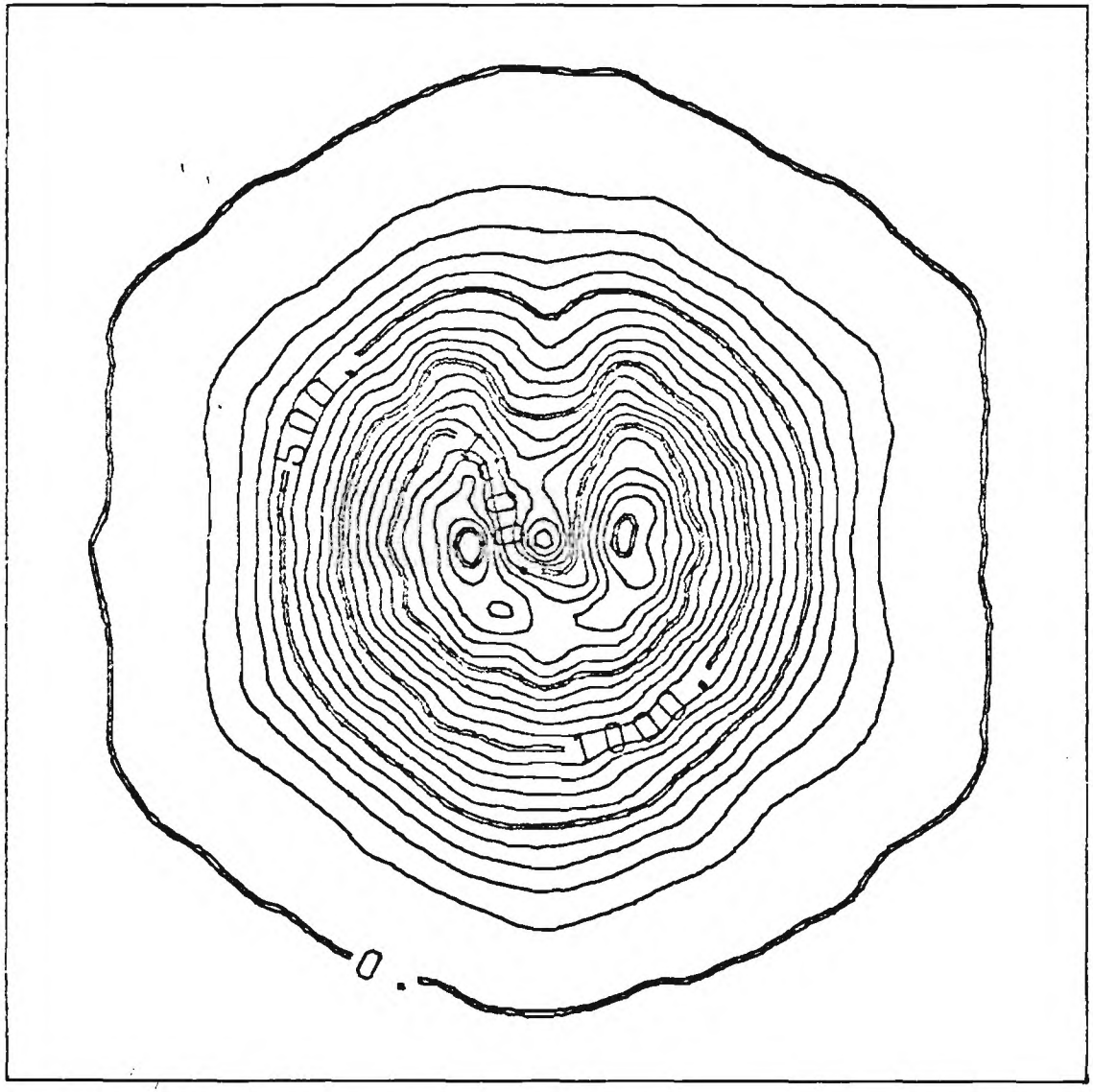


FIGURE 59

Radius Error Test, 10 cm Avg. Error
Full Dish, Cone @ 30 cm
Slope Error = 0
Power = 88.7877 kw
Peak Flux = 198.06
Contour Interval = 100

Flux Value at 90% Power:	184.90 KW/SQ M
Area Inside 90% Power Contour:	1604.81 SQ CM
Power Inside 90% Power Contour:	81.52 KILOWATTS
90% Total Power (Check):	79.73 KILOWATTS